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THE MESOSPHERS AND.. (U) AIR FORCE GEOPHYSICS LAB
HANSCOM AFB MA T J KENESHEA ET AL. 07 MAR 84
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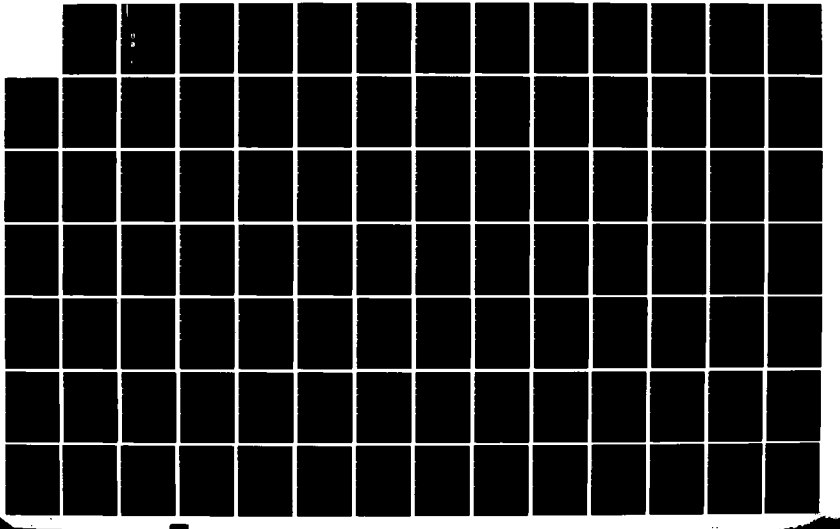

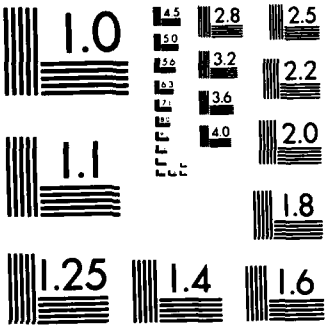

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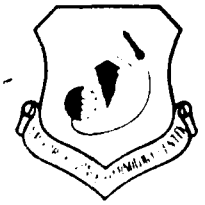
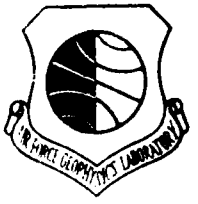
AFGL-TR-84-0183
ENVIRONMENTAL RESEARCH PAPERS, NO. 886

A Computer Code for a One-Dimensional Dynamic Model of the Mesosphere and Lower Thermosphere

T. J. KENESHEA
S. P. ZIMMERMAN





7 March 1984

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SECURITY CLASSIFICATION OF THIS PAGE

AD-A157122

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) AFGL-TR-84-0183, ERP No. 886	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Air Force Geophysics Laboratory 6b. OFFICE SYMBOL (If applicable) LYD	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State and ZIP Code) Hanscom AFB Massachusetts 01731	7b. ADDRESS (City, State and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State and ZIP Code)	10. SOURCE OF FUNDING NOS. PROGRAM ELEMENT NO. 62101F; PROJECT NO. 6670; TASK NO. 18; WORK UNIT NO. 03
11. TITLE (Include Security Classification) A Computer Code for a One-Dimensional Dynamic (Contd)	
12. PERSONAL AUTHOR(S) Keneshea, T.J.; Zimmerman, S.P.	
13a. TYPE OF REPORT Scientific 13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Yr., Mo., Day) 1984 March 7 15. PAGE COUNT 222
16. SUPPLEMENTARY NOTATION	
17. COSATI CODES FIELD / GROUP / SUB. GR.	18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Mesosphere Lower thermosphere Dynamic computer model

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

A one-dimensional computer simulation of the composition and the dynamics of the mesosphere and lower thermosphere between 50 and 400 km is presented. The model is based on a numerical solution of large sets of partial differential equations for the conservation of mass and momentum for individual gases in an atmosphere with constant temperature and turbulent diffusion coefficient profiles. Incorporated into the model are 56 different neutral and ionic atmospheric species involved in 215 chemical and photochemical reactions. Distributions of many of the constituents are presented as determined from an application of the computer code to a midlatitude winter environment. Included are tables of the photodissociation rate coefficients as functions of the column densities of molecular oxygen and ozone for several of the atmospheric gases. Finally, the complete computer code is presented along with a detailed explanation of its structure and instructions for its use.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Thomas J. Keneshea	22b. TELEPHONE NUMBER (Include Area Code) 617-861-3317 22c. OFFICE SYMBOL LYD

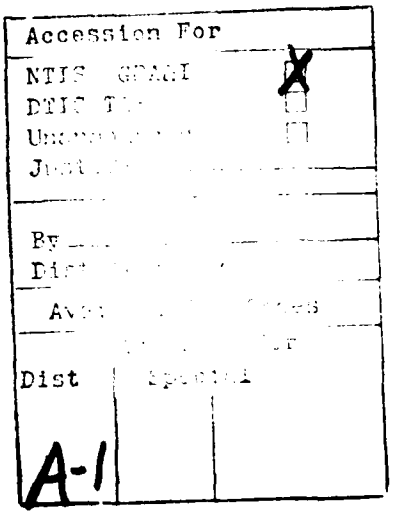
DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

Block 19. (Contd)

Model of the Mesosphere and Lower Thermosphere



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A Computer Code for a One-Dimensional Dynamic Model of the Mesosphere and Lower Thermosphere

1. INTRODUCTION

T.J. Keneshea, one of the authors, pioneered studies of the numerical solution of sets of continuity equations in the atmosphere. He was the first to find that these equations were "stiff" and were not solvable efficiently by any numerical technique then available. His efforts[1,2,3] led to a computer simulation of the composition of the upper atmosphere that could be run inexpensively on the large scale computers available in those days. After these computer codes were applied to the undisturbed atmosphere[4] and to several natural[5] and manmade atmospheric disturbances, it became apparent that they could not predict long term atmospheric behavior.

(Received for publication 1 March 1984)

1. Keneshea, T.J. (1962) A Computer Program for Solving the Reaction Rate Equations in the E Ionospheric Region, AFCRL-62-828.
2. Keneshea, T.J. (1963) A Solution to the Reaction Rate Equations in the Atmosphere Below 150 Kilometers, AFCRL-63-711.
3. Keneshea, T.J. (1967) A Technique for Solving the General Reaction Rate Equations in the Atmosphere, AFCRL-67-0221, AD654010.
4. Keneshea, T.J., Narcisi, R.S., and Swider, W., Jr. (1970) Diurnal model of the E-region, J. Geophys. Res. 75:845-854.
5. Keneshea, T.J., and Fowler, R.J. (1966) Computed Electron, Ion, and Neutral Density Profiles for the Solar Eclipse of 12 November 1966, AFCRL-66-741, AD646975.

Such simple computer codes, in which only chemical reactions among the atmospheric gases are considered, are excellent for determining short term variations of the atmosphere, but give completely erroneous results for solutions beyond a few hours. In fact, these codes are valid only for solution times shorter than the transport time constants for the various atmospheric gases.

It then became obvious that any realistic atmospheric simulation should be based upon the equations of motion for the particles as well as their continuity equations. This report describes in detail a computer scheme for solving large sets of coupled partial differential equations of conservation of mass and momentum and also presents the computer code itself with instructions for using it. Also included are the results of an application of the code to the development of a one-dimensional midlatitude winter simulation of the composition of the mesosphere and lower thermosphere.

2. THE EQUATIONS OF STATE

The equation for the conservation of particles of a particular gas within a multicomponent gas mixture is

$$\frac{\partial n_i}{\partial t} = P_i - n_i L_i - \nabla \cdot \vec{\Phi}_i \tag{1}$$

where n_i is the concentration of species i, P_i is the rate at which it is formed, and $n_i L_i$ is the rate at which it is removed through gas phase chemical reactions with other members of the ensemble. The vector flux of the species, $\vec{\Phi}_i$, is induced by a combination of all nonchemical processes. In this report, only molecular and eddy diffusion will be considered in the flux term

$$\vec{\Phi}_i = n_i \vec{C}_i + n_i \vec{V}_i \tag{2}$$

where $\vec{C}_i$ is the velocity of species i resulting from molecular diffusion and $\vec{V}_i$ is the velocity resulting from eddy diffusion. Since only the vertical distribution of species is to be considered here, the continuity equation can be written as

$$\frac{\partial n_i}{\partial t} = P_i - n_i L_i - \frac{\partial}{\partial Z}(n_i w_i + n_i v_i) \tag{3}$$

where w_i and v_i are the vertical components of the velocities $\vec{C}_i$ and $\vec{V}_i$ respectively.

The equation of motion for a neutral gas particle in a multicomponent gas mixture can be written as[6]

$$\frac{\partial \vec{C}_i}{\partial t} + \frac{1}{\rho_i} \nabla p_i + \frac{\alpha_i p_i}{\rho_i} \nabla \ln T - \vec{g} = - \sum_j \nu_{ij} (\vec{C}_i - \vec{C}_j) \tag{4}$$

where $\rho_i = n_i m_i$ is the mass density of species i, α_i is its thermal diffusion factor in a multicomponent mixture, p_i is its partial pressure, T is the temperature of the mixture, $\vec{g}$ is the acceleration of gravity, and ν_{ij} is the collision frequency of species i with species j. The equation of motion is written here in terms of the collision frequencies between particles rather than the molecular diffusion coefficients in a multicomponent gas as was done by Keneshea and Zimmerman[7] and Keneshea et al.[8] The pressure of the gas is simply

$$p_i = n_i k T \tag{5}$$

where k is Boltzmann's constant. Therefore, in the one-dimensional case

$$\frac{1}{\rho_i} \nabla p_i + \alpha_i \frac{p_i}{\rho_i} \nabla \ln T + g = \frac{kT}{m_i} \left[\frac{1}{n_i} \frac{\partial n_i}{\partial Z} + \frac{(1+\alpha_i)}{T} \frac{\partial T}{\partial Z} + \frac{1}{H_i} \right] \tag{6}$$

where m_i is the mass of species i and $H_i = kT/m_i g$ is its scale height. The equation of motion in the vertical direction for a neutral gas particle can then be written as

$$\frac{\partial w_i}{\partial t} + \frac{kT}{m_i} \left[\frac{1}{n_i} \frac{\partial n_i}{\partial Z} + \frac{(1+\alpha_i)}{T} \frac{\partial T}{\partial Z} + \frac{1}{H_i} \right] = - \sum_j \nu_{ij} (w_i - w_j). \tag{7}$$

If inertial effects are ignored, then the equation of motion for ions and electrons in the presence of both magnetic and electric fields are[9]

---

6. Chapman, S., and Cowling, T.G. (1970) The Mathematical Theory of Non-Uniform Gases, Cambridge University Press

7. Keneshea, T.J., and Zimmerman, S.P. (1970) The effect of mixing upon atomic and molecular oxygen in the 70-170 km region of the atmosphere, J. Atmos. Sci. 27:831-840.

8. Keneshea, T.J., Zimmerman, S.P., and Philbrick, C.R. (1979) A dynamic model of the mesosphere and lower thermosphere, Planet. Space Sci. 27:385-401.

9. Banks, P.M., and Kockarts, G. (1973) Aeronomy, Part A and Part B, Academic Press, New York.

$$\frac{\partial \vec{C}_i}{\partial t} + \frac{1}{\rho_i} \nabla p_i - \vec{g} - \frac{q_i}{m_i} \left(\vec{E} + \frac{1}{c} \vec{C}_i \times \vec{B}\right) = -\sum_j \nu_{ij} \left(\vec{C}_i - \vec{C}_j\right) \tag{8}$$

and

$$\frac{\partial \vec{C}_e}{\partial t} + \frac{1}{\rho_e} \nabla p_e - \vec{g} - \frac{q_e}{m_e} \left(\vec{E} + \frac{1}{c} \vec{C}_e \times \vec{B}\right) = -\sum_j \nu_{ej} \left(\vec{C}_e - \vec{C}_j\right)$$

where q is the particle charge, m is its mass, $\vec{E}$ is the total electric field vector, c is the speed of light, and $\vec{B}$ is the magnetic field vector. After much algebra, ignoring the horizontal component of the electric field as well as the horizontal velocities of the particles, and assuming that the electron and the ion temperatures are the same as the temperature of the neutral gas mixture, the equation of motion for the vertical velocities of the ionic species becomes

$$\frac{\partial w_i}{\partial t} + \frac{kT}{m_i} \left[\frac{1}{n_i} \frac{\partial n_i}{\partial Z} + \frac{1}{n_e} \frac{\partial n_e}{\partial Z} + \frac{2}{T} \frac{\partial T}{\partial Z} + \frac{1}{H_i}\right]$$

$$= - w_i \sum_j \nu_{ij} \left\{ \frac{\Omega_i^2 + \left(\sum_j \nu_{ij}\right)^2}{\Omega_i^2 \sin^2 I + \left(\sum_j \nu_{ij}\right)^2} \right\} + \sum_j \nu_{ij} w_j \tag{9}$$

where n_e is the concentration of the electrons, I is the magnetic dip angle, and

$$\Omega_i = \frac{B_o e}{m_i c} \tag{10}$$

where B_o is the magnitude of the magnetic field and e is the charge on the electron.

The eddy diffusion velocity, taken from the formulation of Colegrove et al,[10] is

$$v_i = -K \left[\frac{1}{n_i} \frac{\partial n_i}{\partial Z} + \frac{1}{T} \frac{\partial T}{\partial Z} + \frac{1}{\bar{H}}\right] \tag{11}$$

where K is the vertical eddy diffusion coefficient and $\bar{H}$ is the scale height of the mean mass.

---

10. Colegrove, F.D., Johnson, F.S., and Hanson, W.B. (1966) Atmospheric composition in the lower thermosphere, J. Geophys. Res. 71:2227-2236.

Whenever a photodissociation rate coefficient is needed in the calculations, the O_2 and O_3 column densities are estimated and a simple table look-up is made for the particular J_j required.

A short discussion of each photodissociation process and the photodissociation rate coefficient tables are presented in Appendix B.

6.2 The Photoionization Rate Coefficients

Reactions 185 through 191 and reactions 206 and 207 in the list of reactions in Appendix A are the photoionization processes considered in this report. The EUV solar fluxes, the total absorption cross sections for O_2, N_2, and O, and the ionization cross sections for O_2, N_2, O, H, and He are listed in Table B21. The EUV solar fluxes from 1 to 121.57 nm are from the compilation of Manson.[18] The X-ray fluxes below 1 nm are taken from Swider.[19] The cross sections for total absorption and for total photoionization of O_2, N_2, and O were obtained from a consideration of reported experimental and theoretical values. References, definitions, and a discussion of the absorption spectra can be found in Huffman[20] for wavelengths to 30.4 nm. For shorter wavelengths, the values given by Swider[19] were used. A discussion of some photoionization rate coefficients can be found in Keneshea and Huffman.[21] The photoionization cross sections for N, H, and He are taken from Banks and Kockarts.[9]

The photoionization of the metastable $O_2(^1\Delta g)$ molecule has been included in these calculations. The wavelength region of interest is from 102.7 to 111.8 nm, where ground state O_2 is the primary absorber of the incident solar radiation but is not ionized itself. The effective absorption coefficient for O_2 and the ionization cross section for $O_2(^1\Delta g)$ are taken from Huffman et al.[22] Nitric oxide is ionized readily by Lyman α radiation. The ionization cross section for NO at Lyman α is 2×10^{-18} cm^2 as given by Watanabe.[23]

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18. Manson, J.E. (1976) Satellite Measurements of Solar UV During 1974, AFCRL-TR-76-0006, AD A021490.

19. Swider, W., Jr. (1969) Ionization rates due to the attenuation of 1-100A nonflare solar X rays in the terrestrial atmosphere, Rev. Geophys. 7:573-594.

20. Huffman, R.E. (1972) Photochemical processes. Cross-section data, Chapter 12, in Defense Nuclear Agency Reaction Rate Handbook, DNA 1948H.

21. Keneshea, T.J., and Huffman, R.E. (1972) Solar Photoionization Rate Constants and Ultraviolet Intensities, AFCRL-72-0667.

22. Huffman, R.E., Paulsen, D.E., Larrabee, J.C., and Cairns, R.B. (1971) Decrease in D-region O_2 ($^1\Delta g$) photoionization rates resulting from CO_2 absorption, J. Geophys. Res. 76:1028-1038.

23. Watanabe, K. (1954) Photoionization and total absorption cross sections of gases. I. Ionization potentials of several molecules. Cross sections of NH_3 and NO, J. Chem. Phys. 22:1564-1570.

The total rate coefficient is obtained simply by summing $J_j(\lambda)$ over all the wavelengths.

$$J_j = \sum_{\lambda} \sigma'_j(\lambda)\, I_o(\lambda)\, e^{-\sum_i \sigma_i(\lambda) N_i} . \tag{54}$$

6.1 The Photodissociation Rate Coefficients

Reactions 192 through 205 in the list of reactions in Appendix A are the photodissociation processes considered in this report. In computing the transmittance, only molecular oxygen and ozone are considered as absorbers of the solar radiation. In addition to these two species, the absorption and subsequent photodissociation of H_2O, H_2O_2, NO_2, NO_3, N_2O, HNO_2, CO_2, and HO_2 are discussed in Appendix B. Also presented in Appendix B are the photodissociation of N_2O_5, HNO_3, CH_4, and CH_2O, even though these species are not included in the aeronomic calculations discussed in this report.

The incident solar flux $I_o(\lambda)$ and the absorption cross sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O used in calculating the photodissociation rate coefficients are listed in Table B1. The cross sections for O_2 in the wavelength region of the Schumann Runge bands (175-205 nm) are not tabulated here. In this wavelength region, the molecular oxygen dissociation data of Hudson and Mahle[15] are used. The incident solar fluxes listed here are those tabulated by Ackerman.[16] In the wavelength region 123 to 190 nm, however, the Ackerman fluxes have been replaced by the measurements of Heroux and Swirbalus.[17] The absorption cross sections for N_2O_5, HNO_2, HNO_3, CH_4, CO_2, CH_2O, and HO_2 are listed in Table B2.

In computing the time dependence of atmospheric composition, the computation of the photodissociation rate coefficients using Eq. (54) can be a time consuming process. As the solar zenith angle changes, the column densities N_i will change and, with them, the J_j's. It is desirable to have available tables of these coefficients that are not dependent upon specific distributions of molecular oxygen and ozone. To keep the tables perfectly general, therefore, the coefficients are computed and tabulated in Appendix B as functions of the column densities of O_2 and O_3.

---

15. Hudson, R.D., and Mahle, S.H. (1972) Photodissociation rates of molecular oxygen in the mesosphere and lower thermosphere, J. Geophys. Res. 77:2902-2914.

16. Ackerman, M. (1971) Ultraviolet solar radiation related to mesospheric processes, in Mesospheric Models and Related Experiments, G. Fiocco, Ed., D. Reidel, Dordrecht, Netherlands.

17. Heroux, L., and Swirbalus, R.A. (1976) Full-disc solar flares between 1230 and 1940 A, J. Geophys. Res. 81:436-440.

the composition of the atmosphere is computed, the dissociation and ionization of atmospheric gases by incident solar radiation must be considered. In most calculations, these photoprocesses are handled as chemical reactions. Consequently, the rate coefficients for dissociation and ionization of the various gases must be known.

The photodissociation and photoionization rate coefficients for a gas particle at any altitude in the atmosphere is a product of the flux of the solar radiation arriving at that altitude and its photodissociation, or photoionization cross section. Several excellent reviews of the absorption properties of atmospheric gases can be found in the literature. Among these are Hudson[12] and Johnston and Graham.[13] Also, an excellent survey article by Turco[14] includes a discussion of photodissociation processes for several gases.

Beer's Law expresses the fractional transmission of radiation through a gas mixture

$$T(\lambda) = \frac{I(\lambda)}{I_o(\lambda)} = e^{-\tau(\lambda)} \tag{51}$$

where $I_o(\lambda)$ is the intensity of the incident radiation, $I(\lambda)$ is the intensity of the transmitted radiation, and $\tau(\lambda)$ is the optical depth of the absorbing layer, all at the wavelength λ. The optical depth is given by

$$\tau(\lambda) = \sum_i \sigma_i(\lambda) N_i \tag{52}$$

where $\sigma_i(\lambda)$ is the absorption cross section of the i'th type of particle and N_i is the total number of particles of this type in a cm^2 column along the ray path to the sun.

The rate coefficient for the photoprocess for j-type particles at wavelength λ is determined by

$$J_j(\lambda) = \sigma_j'(\lambda)\, I_o(\lambda)\, T(\lambda) \tag{53}$$

where $\sigma_j'(\lambda)$ is the cross section for photodissociation or photoionization of the gas.

---

12. Hudson, R.D. (1971) Critical review of ultraviolet photoabsorption cross sections for molecules of astrophysical and aeronomic interest, Rev. Geophys. Space Phys. 9:305-406.

13. Johnston, H.S., and Graham, R. (1974) Photochemistry of NO_x and HNO_x compounds, Can. J. Chem. 52:1415-1423.

14. Turco, R.P. (1975) Photodissociation rates in the atmosphere below 100 km, Geophys. Surveys 2:153-192.

Therefore, the average collision frequency for charge exchange is

$$\overline{\nu}_{in} = 1.73725\, n\, \gamma. \tag{48}$$

The average reduced charge exchange collision frequencies between like particles are given in Table 2. Again, it is assumed that the ion and neutral gas temperatures are equal.

Table 2. The Average Reduced Charge Exchange Collision Frequencies Between Like Particles

$H^+ + H$	1.0×10^{-10}	H	$(2T)^{1/2}$
$O^+ + O$	1.6×10^{-11}	O	$(2T)^{1/2}$
$N^+ + N$	1.7×10^{-11}	N	$(2T)^{1/2}$
$He^+ + He$	3.0×10^{-11}	He	$(2T)^{1/2}$
$O_2^+ + O_2$	1.1×10^{-11}	O_2	$(2T)^{1/2}$
$N_2^+ + N_2$	2.2×10^{-11}	N_2	$(2T)^{1/2}$

The average ion-ion momentum transfer collision frequency is given by

$$\overline{\nu}_{ij} = 1.3\, n_j \left(\frac{1}{\mu^{1/2}\, T^{3/2}} \right) \text{sec}^{-1} \tag{49}$$

assuming that the charge states of the colliding particles are both unity.

The collision frequency between i and j-type particles is then simply

$$\nu_{ij} = \frac{m_i}{(m_i + m_j)}\, \overline{\nu}_{ij}. \tag{50}$$

6. THE CHEMISTRY AND PHOTOCHEMISTRY

The chemical reactions included in this model are listed in Appendix A. When

Table 1. Polarizabilities of Neutral Gases

GAS	$\alpha(10^{-24}\ cm^3)$
N_2	1.76
O_2	1.59
$O_2(^1\Delta g)$	1.59
O	0.79
H	0.667
H_2	0.82
N	1.1
$N(^2D)$	1.1
NO	1.74
He	0.21
N_2O	3.00
CO_2	2.63
CO	1.97

Let

$$\overline{Q}_E = \sigma = \frac{\gamma}{v} \tag{46}$$

where γ is the chemical reaction rate constant and v is the velocity of the colliding particle.

Since

$$v = \left(\frac{3kT}{m}\right)^{1/2}, \text{ then}$$

$$\overline{\nu}_{in} = \frac{4}{3} n \left(\frac{16kT}{\pi m}\right)^{1/2} \frac{\gamma}{\left(\frac{3kT}{m}\right)^{1/2}}. \tag{47}$$

5. COLLISION FREQUENCIES

A good review of collision processes can be found in Banks and Kockarts.[9] All of the material that follows was taken from that source.

The average neutral-neutral collision frequencies are given by

$$\bar{\nu}_{ij} = 2n_j \sigma_{ij}^2 \left(\frac{2\pi kT}{\mu}\right)^{1/2} \text{sec}^{-1} \tag{43}$$

where μ, the reduced mass, is given by

$$\mu = \frac{m_i m_j}{m_i + m_j}$$

and

$$\sigma_{ij} = \frac{1}{2}(\sigma_i + \sigma_j)$$

where σ_i and σ_j are the diameters of the colliding particles.

The average collision frequency for momentum transfer between ions and neutral particles is

$$\bar{\nu}_{in} = 2.6 \times 10^{-9} n_n \left(\frac{\alpha}{\mu}\right)^{1/2} \text{sec}^{-1} \tag{44}$$

where n_n is the concentration of the neutral particles, α is the neutral gas atomic polarizability in units of 10^{-24} cm^3, and μ is in amu. Table 1 lists the polarizability of several atmospheric gases.[9]

The average collision frequency for charge exchange between unlike particles is given by

$$\bar{\nu}_{in} = \frac{4}{3} n \left(\frac{8k}{\pi m}\right)^{1/2} (2T)^{1/2} \bar{Q}_E \tag{45}$$

where $\bar{Q}_E$ is the average charge transfer cross section for ion-neutral collisions. In Eq. (45), the ion and neutral temperatures are assumed to be equal.

The calculation of F_K, however, requires the upper boundary velocity at the end of the time step. At the upper boundary, O_2^+, NO^+, O_3, OH, H, HO_2, H_2O, H_2O_2, H_2, NO_2, O_2 ($^1\Delta g$), and argon are all minor species. It is assumed, therefore, that they are in diffusive equilibrium there. This means that their diffusion velocities are zero at the upper boundary, but they are still subject to the mean mass motion.

The remaining species, however, do have diffusion velocities at the upper boundary that must be defined. It is impossible to calculate the upper boundary velocities from Eq. (18) because concentrations are required at K + 1. Since this altitude is outside the volume, the concentrations are not known there. Therefore, to estimate the velocities at the upper boundary at the end of the time step, we investigate the continuity equation, Eq. (3), at the upper boundary where $v_i = 0$ (since the upper boundary is outside of the turbulence region).

$$\frac{\partial n_i}{\partial t} = P_i - n_i L_i - \frac{\partial}{\partial Z}(n_i w_i). \tag{41}$$

Setting the time derivative to zero and solving the resulting equation for dw_i/dZ gives

$$\frac{dw_i}{dZ} = -\frac{w_i}{n_i}\frac{dn_i}{dZ} + \frac{P_i - n_i L_i}{n_i}. \tag{42}$$

This ordinary differential equation can be solved numerically over the last height step to give values of w_i at the upper boundary. Since Eq. (42) is solved in every iteration, the final iteration will give the upper boundary value of w_i at the end of the time step.

The new concentration profiles at $t + \Delta t$ are therefore computed as follows: Starting at the lower boundary, the E and F arrays are computed in the increasing height direction up to the upper boundary. The new concentrations are then computed starting at the upper boundary and applying Eq. (27) in the decreasing altitude direction down to the lower boundary. This procedure is repeated over each time step until the solutions converge for that time step. Once a solution has been accepted, the time step is doubled (provided it has not reached the maximum value set by the program). Using the concentrations and velocities computed at the end of the last time step, the equations are solved over the next time step. In this manner, the solution advances.

Eq. (36) can be written as

$$\tilde{B}_K^{\ell} n_K^{\ell+1} - \tilde{C}_K^{\ell} n_{K-1}^{\ell+1} = \tilde{D}_K^{\ell} \tag{37}$$

where

$$\tilde{A}_K^{\ell} = 0$$

$$\tilde{B}_K^{\ell} = -A_K^{\ell}\left[1 - \Gamma_K \Delta Z_K - \frac{m_i \Delta Z_K}{k T_K} \sum_j \nu_{ij} (w_i - w_j)_K^{\ell+1}\right] + B_K^{\ell}$$

$$\tilde{C}_K^{\ell} = C_K^{\ell}$$

$$\tilde{D}_K = D_K^{\ell}. \tag{38}$$

Eq. (28) can be rewritten at level K as

$$E_K = \frac{\tilde{A}_K^{\ell}}{[\tilde{B}_K^{\ell} - \tilde{C}_K^{\ell} E_{K-1}]}$$

and

$$F_K = \frac{\tilde{D}_K^{\ell} + \tilde{C}_K^{\ell} F_{K-1}}{\tilde{B}_K^{\ell} - \tilde{C}_K^{\ell} E_{K-1}}. \tag{39}$$

It is obvious, then, that

$$E_K = 0$$

and

$$F_K = \frac{D_K^{\ell} + C_K^{\ell} F_{K-1}}{B_K^{\ell} - A_K^{\ell}\left[1 - \Gamma_K \Delta Z_K - \frac{m_i \Delta Z_K}{k T_K} \sum_j \nu_{ij} (w_i - w_j)_K^{\ell+1}\right] - C_K^{\ell} E_{K-1}}. \tag{40}$$

$$n_o^{\ell+1} = \frac{n_o^{\ell} + P_o^{\ell+1}\,\Delta t}{\left[1 + L_o^{\ell+1}\,\Delta t\right]}. \tag{30}$$

E_o and F_o at the lower boundary are simply

$$E_o = O$$

and

$$F_o = n_o^{\ell+1}. \tag{31}$$

At the upper boundary, the time derivative of the velocities in Eq. (7) is set to zero:

$$\frac{kT}{m_i}\left[\frac{1}{n_i}\frac{dn_i}{dZ} + \frac{(1+\alpha_i)}{T}\frac{dT}{dZ} + \frac{1}{H_i}\right] = -\sum_j \nu_{ij}\,(w_i - w_j). \tag{32}$$

Solving Eq. (32) for dn_i/dZ gives

$$\frac{dn_i}{dZ} = -n_i\,\Gamma_i - \frac{n_i m_i}{kT}\sum_j \nu_{ij}\,(w_i - w_j). \tag{33}$$

Writing Eq. (33) at the upper boundary (K) in finite difference notation gives

$$\frac{n_{K+1}^{\ell+1} - n_K^{\ell+1}}{\Delta Z_K} = n_K^{\ell+1}\,\Gamma_K - \frac{n_K^{+1}\,m_i}{kT_K}\sum_j \nu_{ij}\,(w_i - w_j)_K^{\ell+1}. \tag{34}$$

Solving Eq. (34) for $n_{K+1}^{\ell+1}$ gives

$$n_{K+1}^{\ell+1} = n_K^{\ell+1}\left[1 - \Gamma_K\,\Delta Z_K - \frac{m_i\,\Delta Z_K}{kT_K}\sum_j \nu_{ij}\,(w_i - w_j)_K^{\ell+1}\right]. \tag{35}$$

Replacing $n_{K+1}^{\ell+1}$ in Eq. (25) written at level K with Eq. (35) gives

$$\left\{-A_K^{\ell}\left[1 - \Gamma_K\,\Delta Z_K - \frac{m_i\,\Delta Z_K}{kT_K}\sum_j \nu_{ij}(w_i - w_j)_K^{\ell+1}\right] + B_K^{\ell}\right\}$$

$$n_K^{\ell+1} - C_K^{\ell}\,n_{K-1}^{\ell+1} = D_K^{\ell} \tag{36}$$

From Eqs. (26) and (27), the following definitions are obtained:

$$E_k = \frac{A_k^{\ell}}{\left[B_k^{\ell} - C_k^{\ell} E_{k-1}\right]}$$

and

$$F_k = \frac{D_k^{\ell} + C_k^{\ell} F_{k-1}}{\left[B_k^{\ell} - C_k^{\ell} E_{k-1}\right]}. \tag{28}$$

Using Eqs. (27) and (28), the height profiles for the concentrations can be calculated provided $n_o^{\ell+1}$ and $n_k^{\ell+1}$ can be specified at the lower and upper boundaries respectively. The boundary conditions will be discussed in Section 4.

It should be noted that only some of the terms on the right-hand side of the equations for A_k^{ℓ}, B_k^{ℓ}, C_k^{ℓ}, and D_k^{ℓ} are specified at the beginning of the time step. The chemistry terms and the velocity sums are specified at the end of the time step. Because of this, the solutions require iteration over the time step. At the end of each iteration of the concentrations, the chemistry and the velocities from Eq. (18) are recomputed. New concentrations are then calculated using these updated values. This procedure is repeated until, on successive iterations, the concentrations of all species change by less than 1 percent at all altitudes.

4. BOUNDARY CONDITIONS

At the lower boundary, the concentrations of N_2, O_2, H_2O, H_2, and Ar are held fixed for all time at their initial values ($n_o^{\ell+1}$ = constant). All of the other species in the transport mode prove to be chemically controlled at 50 km, so their concentrations are computed from the simplified continuity equations. With the divergence of the flux set to zero in Eq. (1), that equation becomes

$$\frac{dn_i}{dt} = P_i - n_i L_i. \tag{29}$$

If the derivative in Eq. (29) is replaced by simple differences, then, at the lower boundary, we have

in which

$$Q_k = \frac{1}{[1 + \Delta t\, \lambda \sum_j \nu_{ij}]}$$

$$S_k = (1 - \Gamma_k \Delta Z_k)$$

$$\bar{S}_k = (1 - \bar{\Gamma}_k \Delta Z_k).$$

It is possible, therefore, to write a tridiagonal matrix between the lower and upper boundaries for each species using Eq. (21). These tridiagonal matrices are then solved for the vertical distribution of the concentration using the method of Richtmyer and Morton.[11]

Substituting the recurrence relation

$$n_{k-1}^{\ell+1} = E_{k-1}\, n_k^{\ell+1} + F_{k-1} \tag{23}$$

into Eq. (21) gives

$$-A_k^{\ell}\, n_{k+1}^{\ell+1} + B_k^{\ell}\, n_k^{\ell+1} - C_k^{\ell} E_{k-1}\, n_k^{\ell+1} - C_k^{\ell} F_{k-1} = D_k^{\ell}. \tag{24}$$

This can be written as

$$-A_k^{\ell}\, n_{k+1}^{\ell+1} + [B_k^{\ell} - C_k^{\ell} E_{k-1}]\, n_k^{\ell+1} = D_k^{\ell} + C_k^{\ell} F_{k-1}. \tag{25}$$

Solving Eq. (25) for $n_k^{\ell+1}$ gives

$$n_k^{\ell+1} = \frac{A_k^{\ell}}{\left[B_k^{\ell} - C_k^{\ell} E_{k-1}\right]} n_{k+1}^{\ell+1} + \frac{D_k^{\ell} + C_k^{\ell} F_{k-1}}{\left[B_k^{\ell} - C_k^{\ell} E_{k-1}\right]}. \tag{26}$$

Eq. (23) written at level k is

$$n_k^{\ell+1} = E_k\, n_{k+1}^{\ell+1} + F_k. \tag{27}$$

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11. Richtmyer, R.D., and Morton, K.W. (1967) Difference Methods for Initial-Value Problems, Interscience Publishers, New York.

$$\phi_{k-1}^{\ell+1} = \frac{1}{\left[1 + \Delta t \lambda_i \sum_j \nu_{ij}\right]} \left\{ n_{k-1}^{\ell+1} w_{k-1}^{\ell+1} - \frac{kT_{k-1}}{m_i} \frac{\Delta t}{\Delta Z_{k-1}} \right.$$

$$\left[n_k^{\ell+1} - n_{k-1}^{\ell+1} (1 - \Gamma_{k-1} \Delta Z_{k-1}) \right]$$

$$\left. + n_{k-1}^{\ell+1} \Delta t \sum_{j \neq i} \nu_{ij} w_{j_{k-1}}^{\ell+1} \right\}$$

$$- \frac{K_{k-1}}{\Delta Z_{k-1}} \left\{ n_k^{\ell+1} - n_{k-1}^{\ell+1} (1 - \bar{\Gamma}_{k-1} \Delta Z_{k-1}) \right\}. \qquad (20)$$

Substituting Eqs. (19) and (20) into Eq. (12) and collecting like terms in n gives

$$- A_k^{\ell} n_{k+1}^{\ell+1} + B_k^{\ell} n_k^{\ell+1} - C_k^{\ell} n_{k-1}^{\ell+1} = D_k^{\ell} \qquad (21)$$

where

$$A_k^{\ell} = \frac{\Delta t}{\Delta Z_k \Delta Z_{k-1}} \left[Q_k \frac{kT_k \Delta t}{m} + K_k \right]$$

$$B_k^{\ell} = 1 + L_k^{\ell+1} \Delta t + \frac{\Delta t}{\Delta Z_k \Delta Z_{k-1}}$$

$$\left[Q_k \left(w_k^{\ell} \Delta Z_k + S_k \frac{kT_k \Delta t}{m} + \Delta t \Delta Z_k \sum_{j \neq i} \nu_{ij} w_k^{\ell+1} \right) \right.$$

$$\left. + \bar{S}_k K_k + Q_{k-1} \frac{kT_{k-1} \Delta t}{m} \frac{\Delta Z_k}{\Delta Z_{k-1}} + K_{k-1} \frac{\Delta Z_k}{\Delta Z_{k-1}} \right]$$

$$C_k^{\ell} = \frac{\Delta t}{\Delta Z_k \Delta Z_{k-1}} \left[Q_{k-1} \left(w_{k-1}^{\ell} \Delta Z_k + S_{k-1} \frac{kt_{k-1} \Delta t}{m} \frac{\Delta Z_k}{\Delta Z_{k-1}} \right.\right.$$

$$\left.\left. + \Delta t \Delta Z_k \sum_{j \neq i} \nu_{ij} w_{k-1}^{\ell+1} \right) + \bar{S}_k K_{k-1} \frac{\Delta Z_k}{\Delta Z_{k-1}} \right]$$

$$D_k^{\ell} = n_k^{\ell} + P_k^{\ell+1} \Delta t \qquad (22)$$

both computed at level k. Also

$$\lambda_i = \frac{\Omega_i^2 + \left(\sum_j \nu_{ij}\right)^2}{\Omega_i^2 \sin^2 I + \left(\sum_j \nu_{ij}\right)^2} \tag{17}$$

The finite difference equations, Eqs. (13) and (14), can be solved for the velocities $w_k^{\ell+1}$ at the end of the time step:

$$w_k^{\ell+1} = \frac{1}{\left[1 + \Delta t \lambda_i \sum_j \nu_{ij}\right]} \left\{ w_k^{\ell} - \frac{kT_k}{m_i} \frac{\Delta t}{\Delta Z_k} \left[\frac{n_{k+1}^{\ell+1} - n_k^{\ell+1}}{n_k^{\ell+1}} + \Gamma_k \Delta Z_k \right] + \Delta t \sum_j \nu_{ij} w_{j_k}^{\ell+1} \right\} \tag{18}$$

This equation holds for both the ionic and neutral species using the above definitions of Γ_k and with $\lambda_i = 1$ for the neutral species. The total molecular and eddy diffusion flux at level k can then be written as

$$n_k^{\ell+1} w_k^{\ell+1} = \Phi_k^{\ell+1} = \frac{1}{\left[1 + \Delta t \lambda_i \sum_j \nu_{ij}\right]} \left\{ n_k^{\ell+1} w_k^{\ell} - \frac{kT_k}{m_i} \frac{\Delta t}{\Delta Z_k} \left[n_{k+1}^{\ell+1} - n_k^{\ell+1} \left(1 - \Gamma_k \Delta Z_k\right) \right] + n_k^{\ell+1} \Delta t \sum_{j \neq i} \nu_{ij} w_{j_k}^{\ell+1} \right\} - \frac{K_k}{\Delta Z_k} \left\{ n_{k+1}^{\ell+1} - n_k^{\ell+1} \left(1 - \bar{\Gamma}_k \Delta Z_k\right) \right\} \tag{19}$$

where

$$\bar{\Gamma}_k = \frac{1}{T_k} \frac{\partial T}{\partial Z} + \frac{1}{\bar{H}} \quad \text{and} \quad \bar{H} = \frac{kT}{\bar{m}g}.$$

A similar expression can be derived for $\Phi_{k-1}^{\ell+1}$ at level k-1.

3. THE FINITE DIFFERENCE EQUATIONS

If 1 denotes the grids on the time mesh and k the grids on the height mesh, then the continuity equations, Eq. (1), can be written in finite difference notation at the height level k as

$$\frac{n_k^{\ell+1} - n_k^{\ell}}{\Delta t} = P_k^{\ell+1} - n_k^{\ell+1} L_k^{\ell+1} - \frac{\Phi_k^{\ell+1} - \Phi_{k-1}^{\ell+1}}{\Delta Z_{k-1}} \tag{12}$$

where, for the sake of clarity, the subscript i has been dropped. Using the equations of motion, Eqs. (7) and (9), the $\Phi_k^{\ell+1}$ and $\Phi_{k-1}^{\ell+1}$ will be replaced in Eq. (12) with their equivalent expressions.

The equations of motion, Eq. (7), for the neutral species can be written in finite difference form at height level k as

$$\frac{w_k^{\ell+1} - w_k^{\ell}}{\Delta t} = -\frac{k T_k}{m_i}\left[\frac{n_{k+1}^{\ell+1} - n_k^{\ell+1}}{n_k^{\ell+1}\ \Delta Z_k} + \Gamma_k\right] - w_k^{\ell+1} \sum_j \nu_{ij}$$

$$+ \sum_{j \neq i} \nu_{ij}\, w_{jk}^{\ell+1} \tag{13}$$

and Eq. (9) for the ionic species as

$$\frac{w_k^{\ell+1} - w_k^{\ell}}{\Delta t} = -\frac{k T_k}{m_i}\left[\frac{n_{k+1}^{\ell+1} - n_k^{\ell+1}}{n_k^{\ell+1}\ \Delta Z_k} + \Gamma_k\right] - w_k^{\ell+1} \lambda_i \sum_j \nu_{ij}$$

$$+ \sum_{j \neq i} \nu_{ij}\, w_{jk}^{\ell+1}. \tag{14}$$

For the neutral species,

$$\Gamma_k = \frac{(1+\alpha_i)}{T}\frac{\partial T}{\partial Z} + \frac{1}{H_i} \tag{15}$$

and for the ionic species

$$\Gamma_k = \frac{1}{n_e}\frac{\partial n_e}{\partial Z} + \frac{2}{T}\frac{\partial T}{\partial Z} + \frac{1}{H_i} \tag{16}$$

In computing the transmittance of EUV radiation, O, O_2, and N_2 are considered as the primary absorbers. The photoionization rate coefficients are computed by using Eq. (54), where the sum is taken from 0.1 to 102.57 nm. Radiation below 15 nm is considered to be X-rays, and its ionization is partitioned among O, O_2, N_2, and N in accordance with Swider.[19]

The calculations also take into account the scattering of some radiation from the sunlit hemisphere into the nighttime hemisphere. These scattered radiations include Lyman α at 121.57 nm, Lyman β at 102.57 nm, the HE I line at 58.4 nm, and the HE II line at 30.4 nm. For simplicity, the amount of radiation that scatters into the dark hemisphere is taken to be a fraction of the direct noontime radiation at the particular altitude under consideration. These fractions are: Lyman α, 0.01; Lyman β, 0.004; HE I, 0.0011; and HE II, 0.001.

Finally, the contribution of cosmic rays to the photoionization rate coefficients is also included. This is simply[24]

$$q_i = 1 \times 10^{-17} n_i. \tag{55}$$

6.3 Electron Impact Ionization

Reactions 208 through 215 in the list of reactions in Appendix A are the energetic electron processes. The flux of energetic electrons appropriate to the calculations made here were supplied by Jasperse.[25] The ionization rate coefficients for the energetic electron reactions are computed from[9]

$$I = \int_{\xi} \sigma(\xi)\Phi(\xi)\,d\xi \tag{56}$$

where $\sigma(\xi)$ is the electron impact ionization cross section and $\Phi(\xi)$ is the energetic electron flux, both at energy ξ. The ionization cross section is given by[9]

$$\sigma(\xi) = \int_{I}^{\frac{\xi + I}{2}} S(\xi, W)\,dW \tag{57}$$

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24. Nicolet, M., and Aikin, A.C. (1960) The formation of the D region of the ionosphere, J. Geophys. Res. 65:1469-1483.

25. Jasperse, J.R. (1978) Private communication.

in which

$$S(\xi, W) = \left(\frac{q_o c_o f_o}{W^2}\right)\left(\frac{I}{W}\right)^P \left[1 - \left(\frac{W}{E}\right)^\gamma\right]^\nu \left(\frac{W}{\xi}\right)^\Omega$$

where I is the ionization threshold for a particular ion state, $q_o = 6.51 \times 10^{-14}$ ev^2 cm^2, $c_o f_o$ is a constant, W is the excitation threshold energy in ev, and P, γ, ν, and Ω are parameters obtained from the best fit of Eq. (58) to experimental and theoretical results. Table B22 lists the values of these parameters used in the model presented here. The values of the rate coefficients computed for the energetic electron reactions are given in Table B23.

6.4 The Thermal Diffusion Factors

The thermal diffusion factors are assumed to be zero except for the following species: O(-0.27), O_2(+0.08), H(-0.39), H_2(-0.31), and He(-0.36). A discussion of the thermal diffusion factors can be found in Zimmerman and Keneshea,[26] from which source these values were taken.

7. A MID-LATITUDE ATMOSPHERE SIMULATION

The computer code presented here describes the distribution of 56 individual atmospheric species. Not all of them have the full coupled sets of equations in the system, however. Some gases in the atmosphere have such short chemical time constants that they will react chemically long before they can be moved out of a unit volume by any transport process. The vertical distribution of these species can be determined quite accurately by considering only the chemical reactions in which they are involved and ignoring any transport effects on them.

The species for which the coupled sets of mass and momentum equations are solved are:

O	H	N	CO	AR	H^+
O_2	H_2	$N(^2D)$	CO_2		HE^+
$O_2(^1\Delta g)$	HO_2	N_2			O^+
O_3	H_2O	NO			O_2^+
OH	H_2O_2	NO_2			NO^+
		N_2O			N^+

Those species whose distributions are determined neglecting transport are

26. Zimmerman, S.P., and Keneshea, T.J. (1976) The thermosphere in motion, J. Geophys. Res. 81:3187-3197.

$O(^1D)$, N_2^+, $O^+(^2D)$, and the electrons. The height distributions of all 56 species are computed over the entire altitude range, which is from 50 to 400 km.

In addition, the vertical distributions of the following species are computed over a reduced altitude range. The temporal variation of these species is also computed with the transport term removed from their continuity equations. The distributions of these species are computed between 50 and 120 km because, above this altitude, they do not exist in significant quantities. These species are:

O^-	O_4^+	$H_5O_2^+.CO_2$	HNO_2
O_2^-	NO_2^+	$O_2^+.H_2O$	NO_3
O_3^-	$H^+.H_2O$	$NO^+.H_2O$	
O_4^-	$H^+.(H_2O)_2$	$NO^+.(H_2O)_2$	
NO_2^-	$H^+.(H_2O)_3$	$NO^+.(H_2O)_3$	
NO_3^-	$H^+.(H_2O)_4$	$NO^+.CO_2$	
CO_3^-	$H_3O^+.N_2$		
CO_4^-	$H_3O^+.OH$		
	$H_3O^+.CO_2$		

Neither negative cluster ions nor metallic ions are considered here. To ensure that the atmosphere remains electrically neutral, one of the negatively charged species is always computed from the imposed condition of balance of charge. Below 120 km, where there are several types of negative ions in addition to the electrons, the most abundant negatively charged species is always computed from conservation of charge. That is, its concentration is computed as the difference between the sum of all the positive and the sum of all the other negative ions. Above 120 km, where the only negatively charged particles are the electrons, their concentration is always set equal to the sum of all the positive ions.

7.1 Initial Conditions

Throughout the development of the time-dependent solution of Eq. (1), the temperatures and the turbulent diffusion coefficients are held fixed at all altitudes in the code presented here. For the simulation developed in this report, both of these parameters were derived from data obtained during the ALADDIN I experiments of

20 November 1970.[27,28] The temperatures shown in Figure 1 between 50 and 125 km were taken from measurements of Theon and Horvath.[29] From 125 to 160 km, the measurements of Golomb[27] were used. Above 160 km, the temperatures were taken from the 900 K exospheric temperature winter model of the U.S. Standard Atmosphere Supplements, 1966. A discussion of the turbulent diffusion coefficients obtained from the ALADDIN I experiments can be found in Keneshea et al.[8] The coefficients presented there represent the minimum turbulent diffusion coefficients determined from the observations on the chemical trails. Following arguments given there, the turbulent diffusion coefficients (Figure 2) used in these calculations are three times larger than those presented in that paper.

Keneshea et al[8] found that stability considerations required that the height steps in the mesosphere not exceed 150 m. In the thermosphere, however, stability could be maintained with somewhat larger height steps. Therefore, to reduce the amount of core storage required for saving the numerous arrays as well as to reduce the amount of computer time per solution, a variable height step array was used. From the lower boundary, 50 km, up to 90 km, the height steps were fixed at 150 m. From 90 km up to the upper boundary, 400 km, the height steps were computed by assuming that they were proportional to the pressure scale height of the atmosphere. This produced an altitude array with 692 grid points, with the maximum height step at the upper boundary of about 1.5 km.

The initial concentration and average velocity profiles were taken from the final solution of an unpublished simulation using turbulent diffusion coefficients one third smaller than those shown in Figure 2. A discussion of a method for establishing initial concentrations on all the species is given in Keneshea et al[8] for a situation where no previous information is available on the vertical distribution of the various species.

The solutions to Eqs. (1) and (18) are started at noon of solution day 1 with the above initial values. Because this is a real time-dependent calculation which takes into account the daily variation of the solar zenith angle, no truly steady state condition on the species concentrations is ever achieved. The calculations are continued, therefore, until all species reproduce their concentrations diurnally at all

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27. Rosenberg, N.W., Golomb, D., Zimmerman, S.P., Vickery, W.K., and Theon, J.S. (1973) The ALADDIN Experiment–Part 1, Dynamics, Space Research XIII, Akademie-Verlag, Berlin, 435-439.

28. Philbrick, C.R., Narcisi, R.S., Good, R.E., Hoffman, H.S., Keneshea, T.J., Macleod, M.A., Zimmerman, S.P., and Reinish, B.W. (1973) The ALADDIN Experiment–Part II, Composition, Space Research XIII, Akademie-Verlag, Berlin, 441-448.

29. Theon, J.S., and Horvath, J.J. (1972) ALADDIN neutral atmosphere measurements, Trans. Am. Geophys. Un. 53:463.

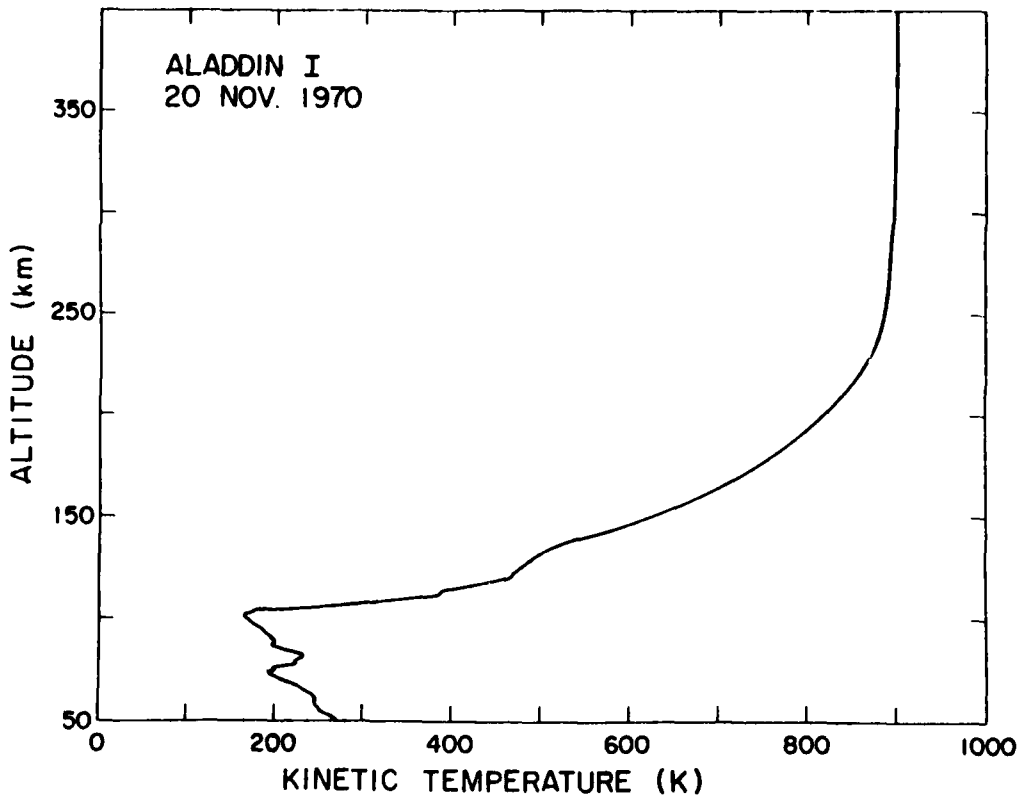

Figure 1. The Static Temperature Profile

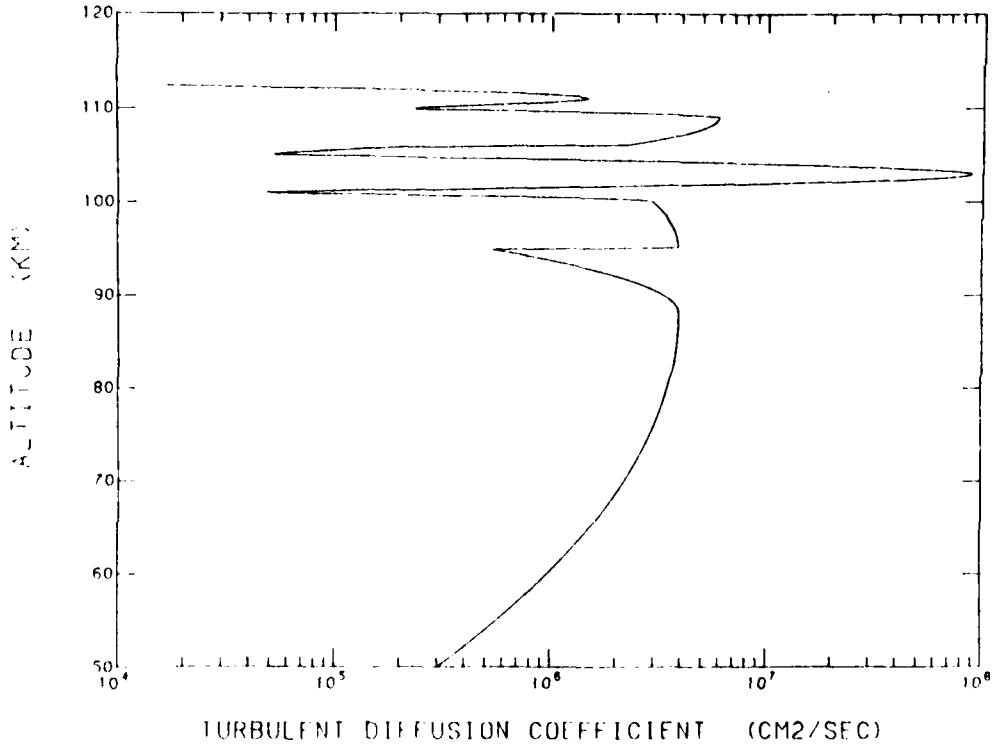

Figure 2. The Turbulent Diffusion Coefficients as Determined From the Chemical Release Data Obtained From the ALADDIN I Experiments

altitudes to within 1 percent. This condition of diurnal reproducibility is generally arrived at after about 20 solution days.

7.2 Thermospheric Results

The results to be discussed here were taken from the final diurnal cycle of the calculations when the major and most of the minor species at all altitudes were varying by no more than 1 percent from values achieved 24 hours earlier. The vertical distribution of the major species N_2, O_2, O, and argon are shown in Figure 3. In this one-dimensional temperature-independent calculation, N_2, O_2, and argon show no diurnal change, having arrived at an equilibrium with the invariant temperature given in Figure 1. Also displayed in Figure 3 is the fixed profile of helium used in these calculations.

Because of the constant temperature profile used here, atomic oxygen also shows no diurnal variation in the thermosphere down to about 120 km. Below this altitude, the chemistry dominates the production (dissociation of O_2) and loss of this species.[7] Thus, we observe in Figures 3 and 4 large diurnal variations of atomic oxygen in the mesosphere.

Presented in Figure 5 are the mesosphere and lower thermosphere noontime profiles of the remaining important neutral species. Carbon dioxide is invariant in the mesosphere and lower thermosphere up to about 140 km. Above this altitude, the diurnal variation of the photodissociation process becomes important in the determination of the carbon dioxide concentrations. The variation of the CO_2/Ar ratio calculated here is shown in Figure 6 and compares well to that determined from atmospheric measurements of Trinks and Fricke.[30]

Isodensity contour plots of the minor neutral species that exhibit a large diurnal variation are shown in Figures 7 to 11. The numbers in all the isodensity plots presented here are the common logarithms of the concentrations. These species, for the most part, are important in the determination of the electron density throughout the atmosphere. Above about 100 km, the charge distribution is dominated by NO^+, O_2^+, O^+, He^+, and H^+. Thus, the resultant thermospheric charge balance follows the chain created primarily by the time-dependent distributions of the neutral species N, NO, and $N(^2D)$ as shown in Figures 7, 8, and 9, respectively. The other neutral thermospheric species in the code have little effect in determining the charge distribution.

The ion and electron isodensity contours determined from these neutrals are shown in Figures 12 to 19. As expected, the dominant positive ion in the upper

30. Trinks, H., and Fricke, K.H. (1978) Carbon dioxide concentrations in the lower thermosphere, J. Geophys. Res. 83:3883-3886.

thermosphere is the O^+ ion. The electron density distribution, therefore, follows the distribution of this ion very closely. Also displayed in Figure 19 is the altitude profile of f_oF_2, the space-time dependence of the peak of the electron density along with the measurements of this parameter by Evans.[31] The correspondence is quite good, clearly demonstrating the midday altitude and amplitude and the nighttime transition to higher altitudes and lower amplitudes. No horizontal winds are included in this one-dimensional simulation; yet, we obtain an excellent representation of the F_2 layer maximum.

Our rationale, then, is that the contribution of chemical production and loss coupled to the convergences and divergences created in our calculations are the main mechanisms that control the amplitude and altitude variation of the F_2 layer maximum. The question that arises from this one-dimensional calculation, which apparently gives good agreement with some F_2 layer maximum measurements, is: What is the effect of horizontal winds? The answer to this question may be inferred from measurements of Reinisch,[32] who determined the time dependence of f_oF_{max} for another period from ionosonde measurements. His results for f_oF_{max} are shown in Figure 20. We observe a smaller peak ionization amplitude than Reinisch does, but, generally, the time dependence of his F_2 layer maximum follows our calculations quite well. Also observed are the large variations that presumably arise from local winds that show multireversals during the measuring period. The point we wish to stress is that ionization calculated from internally determined neutral species distributions does result in an internally consistent F_2 layer ionization behavior that compares well with some of the observed ionic behavior. An example of this is the recent work of Sethia et al,[33] who have performed calculations similar to ours but include the effects of horizontal winds. They determine the distributions along magnetic field lines, while we calculate in the vertical direction with the magnetic field entering by way of the Larmor frequency and the magnetic dip angle. They input the neutral atmosphere, while we calculate it as an internally consistent integral part of the model.

In Figure 21, we have superimposed upon our calculation of the total electron content that taken from Figure 3, model 4 (no winds) of Sethia et al.[33] We observe that the shapes of the distributions are almost identical between the two one-dimensional models. The differences in magnitude can be attributed to the

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31. Evans, J.V. (1971) Observations of F-region vertical velocities at Millstone Hill-I. Evidence for drifts due to expansion, contraction, and winds, Radio Sci. 6:609-626.

32. Reinisch, B. (1983) Private communication.

33. Sethia, G.C., Bailey, G.J., Moffett, R.J., and Hargreaves, J.K. (1983) The effects of neutral air winds on the electron content of the mid-latitude ionosphere and protonosphere in summer, Planet. Space Sci. 31:377-387.

different conditions under which the models were computed. We also compare (Figure 22) the total electron content to some measurements taken at Boulder by Sethia et al[33] as shown in their Figure 8 (July 2, no wind, and July 5, with wind). Again, the shape of our distribution compares well with the measured profiles. For those cases where the wind amplitude is not very large, the contribution of the $\vec{v} \times \vec{B}$ mechanism is very much smaller than that of the chemistry. We make another comparison with the work of Poulter et al[34] shown in Figure 23. Here we examine the total electron content for measurements at Boulder and Lancaster (Figure 5 of Poulter et al), and again quite good agreement is seen between the shape of the distributions from the chemical-transport one-dimensional model and the measurements. The observed differences between the Boulder and the Lancaster curves result from the differences in the raypath geometries. Comparison is also quite good between our calculations and the f_0F_2 measured by Kohl et al[35] and discussed by Risbeth.[36]

We reiterate the point we wish to stress (see also Rush et al[37]): A comprehensive, one-dimensional, time-dependent ion-neutral model demonstrates excellent agreement with measurements of electron densities. The inclusion of the effects of winds is necessary, however, to explain the deviation of the ions and/or electrons from their equilibrium distributions, which significantly vary over the diurnal cycle.

7.3 Mesospheric Results

The ionization in the mesosphere is much more complex than the ionization in the thermosphere. Ablating meteorites create long-lived atomic ions from the metallic species present in the atmosphere. These metallic ions are significant and are observed to be the dominant ions in sporadic E layers. Their chemistry, however, is not well known. For this reason and because large amounts of additional computer memory and time would be required for their inclusion in the transport mode, they have been omitted from the calculations presented here. This omission might explain why our electron density is somewhat low in the 90 to 110 km

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34. Poulter, E.M., Hargreaves, J.K., Bailey, G.J., and Moffet, R.J. (1981) Electron content modelling: The significance of protonospheric contents, Planet. Space Sci. 29:869-883.

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37. Rush, C.M., Kempner, M.P., Anderson, D.N., Stewart, F.G., and Perry, J. (1983) Improving ionospheric maps using theoretically derived values, Radio Sci. 18:95-107.

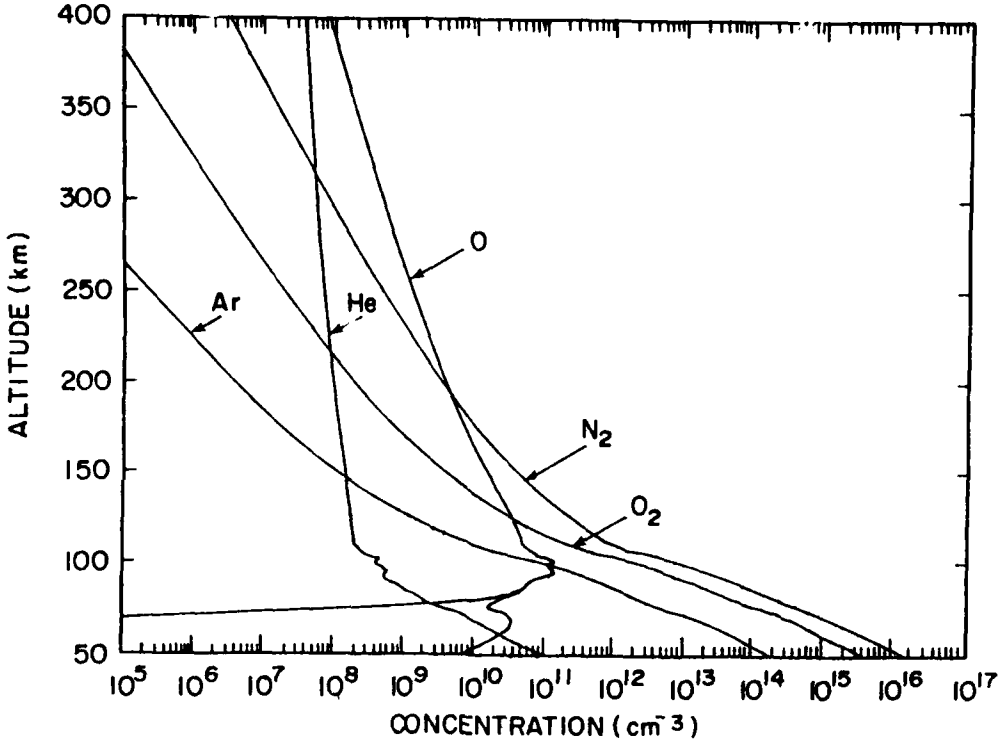

Figure 3. The Time Invariant Height Profiles of N_2, O_2, Helium, and Argon. Above about 100 km, atomic oxygen is also invariant. Below 100 km, the noon and midnight profiles of atomic oxygen are shown

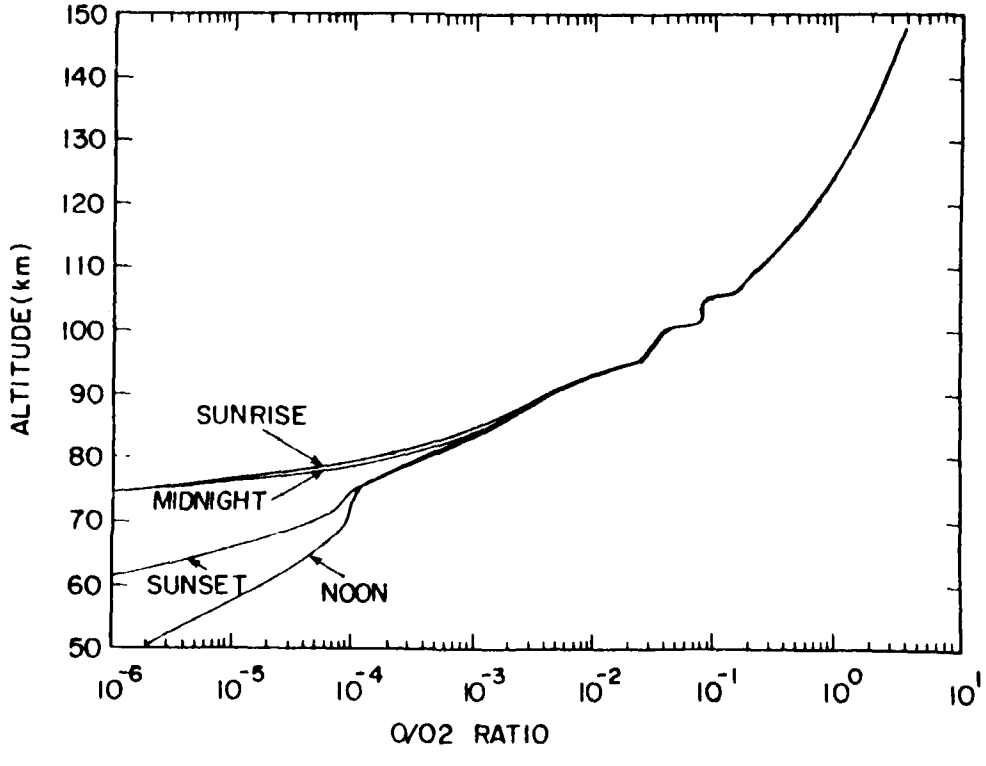

Figure 4. The Ratio of Atomic to Molecular Oxygen at Four Different Times During the Day. These curves reflect the diurnal variations of atomic oxygen in the mesosphere

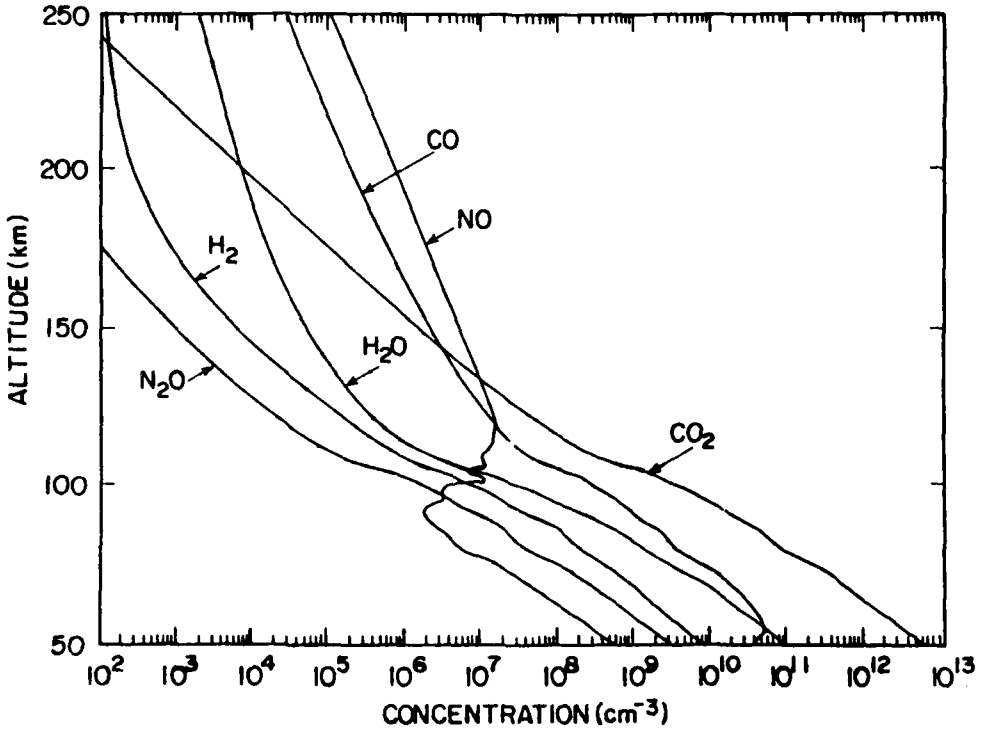

Figure 5. The Noontime Profiles of H_2, H_2O, NO, N_2O, CO, and CO_2 in the Mesosphere and Lower Thermosphere

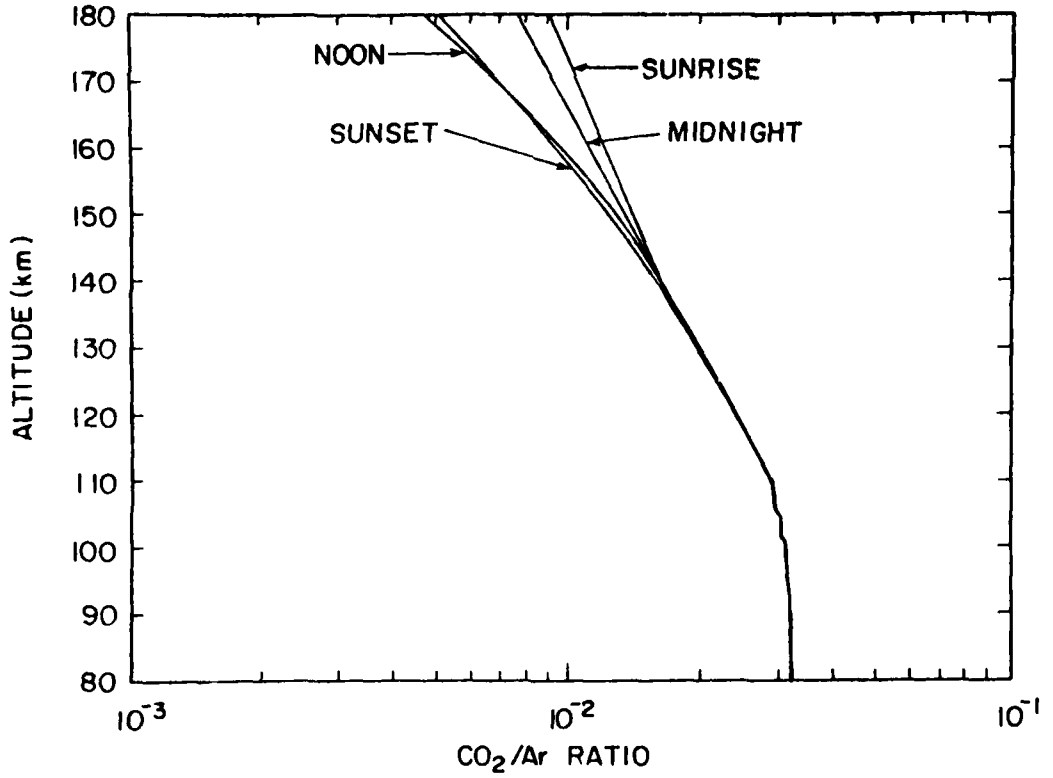

Figure 6. The Ratio of Carbon Dioxide to Argon at Four Different Times During the Day. The curves show the diurnal variation of carbon dioxide in the lower thermosphere

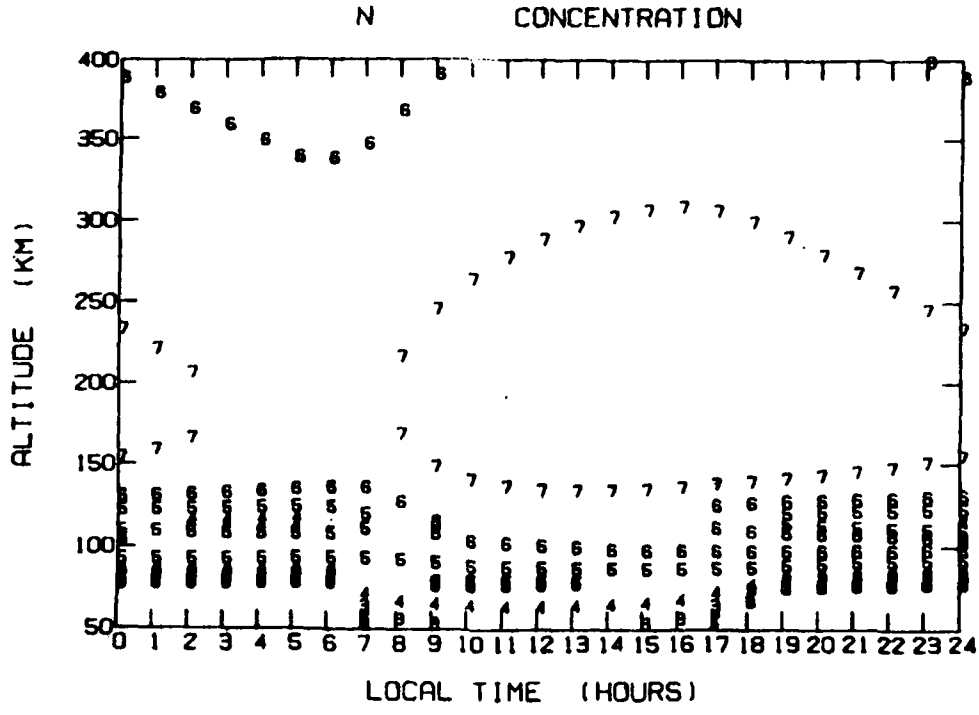

Figure 7. The Iso-Density Contours for Atomic Nitrogen

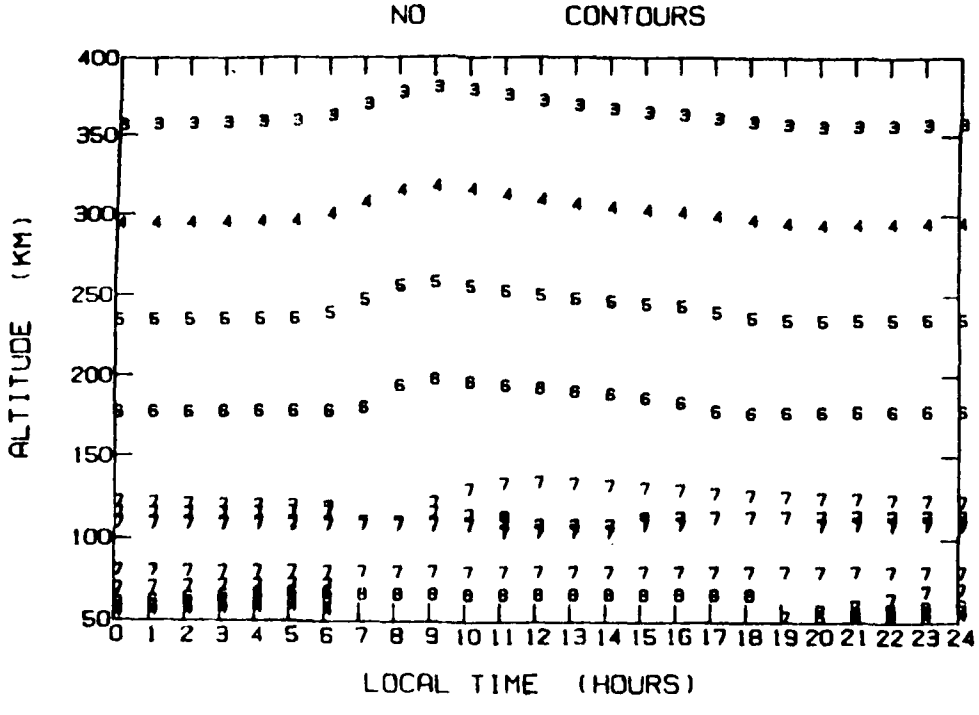

Figure 8. The Iso-Density Contours for Nitric Oxide

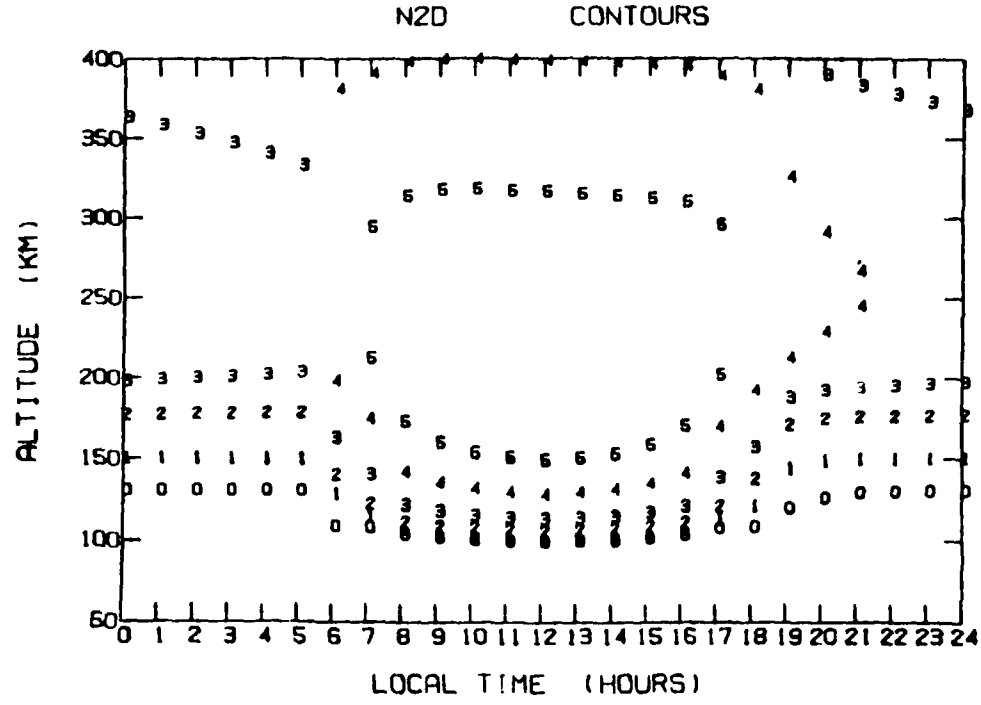

Figure 9. The Iso-Density Contours for N^2D

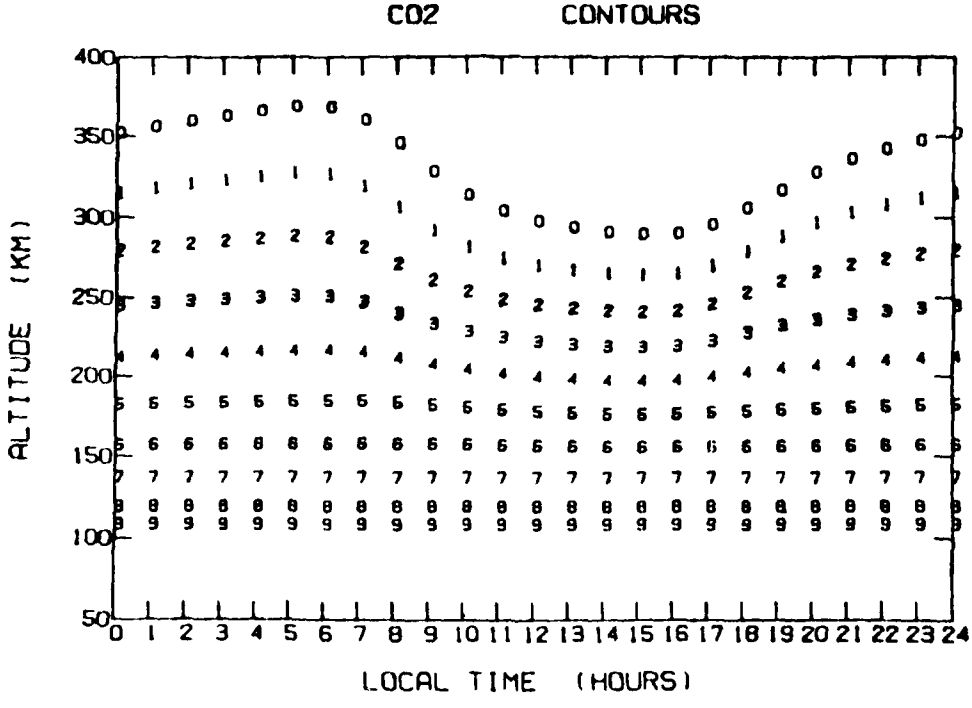

Figure 10. The Iso-Density Contours for Carbon Dioxide. The contours indicate a lack of any diurnal variation for this species below 150 km

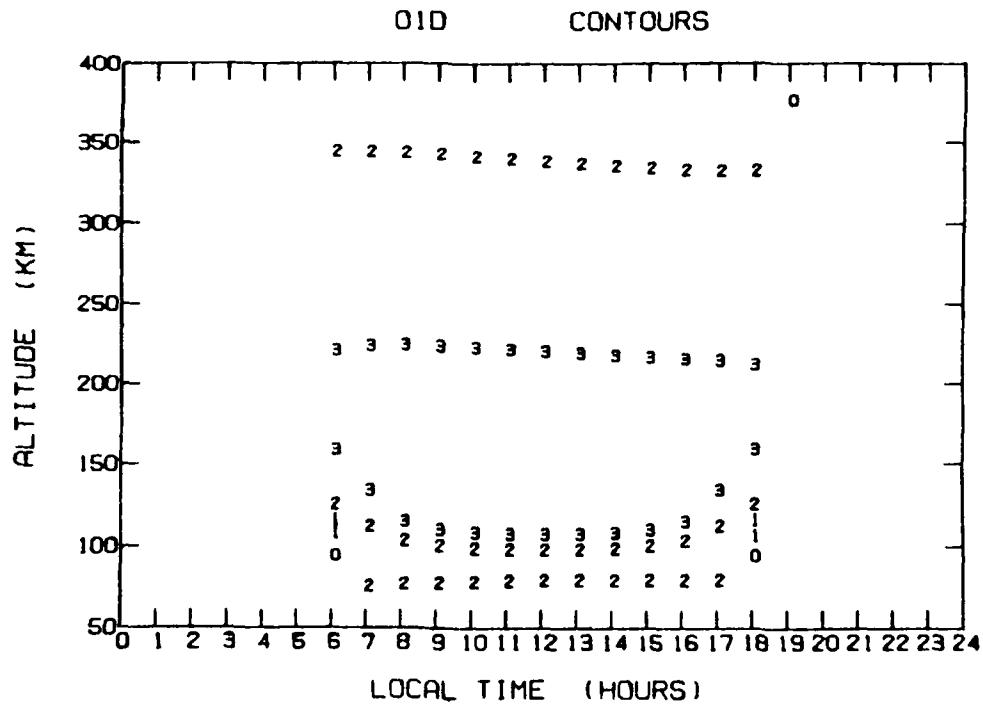

Figure 11. The Iso-Density Contours for O^1D

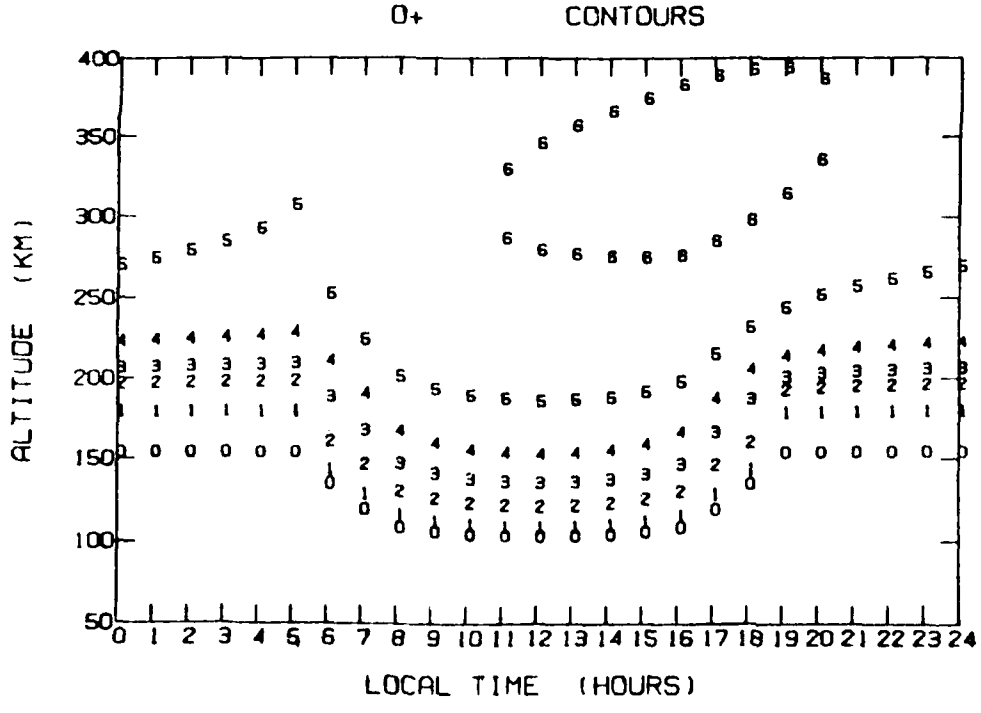

Figure 12. The Iso-Density Contours for O^+. The contours show the daytime F-layer peak ionization in excess of 10^6 cm^{-3}

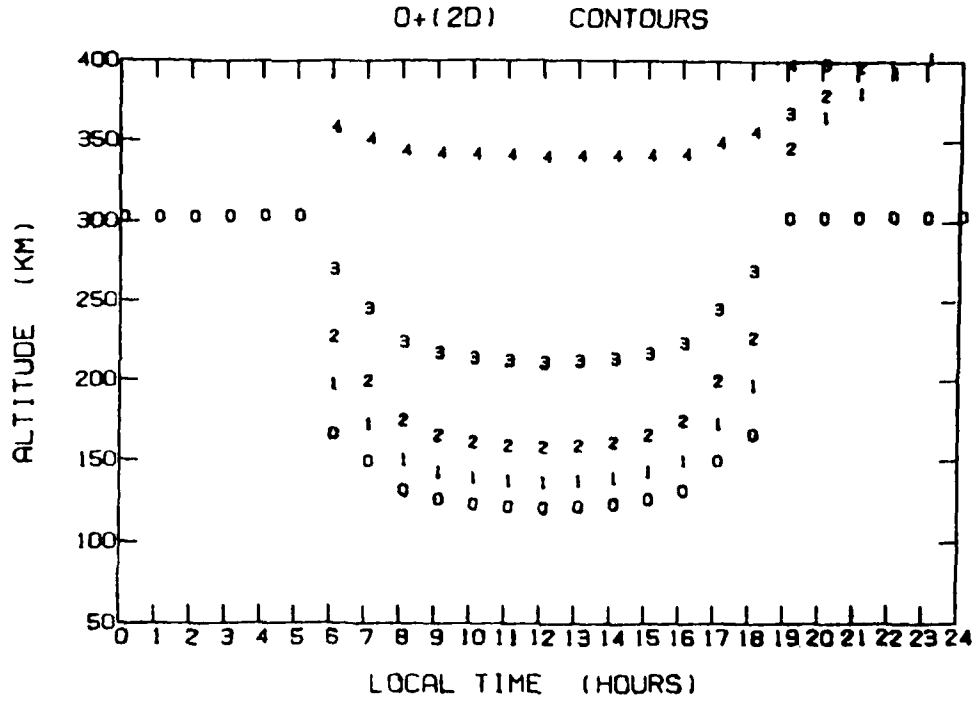

Figure 13. The Iso-Density Contours for $O^+(^2D)$

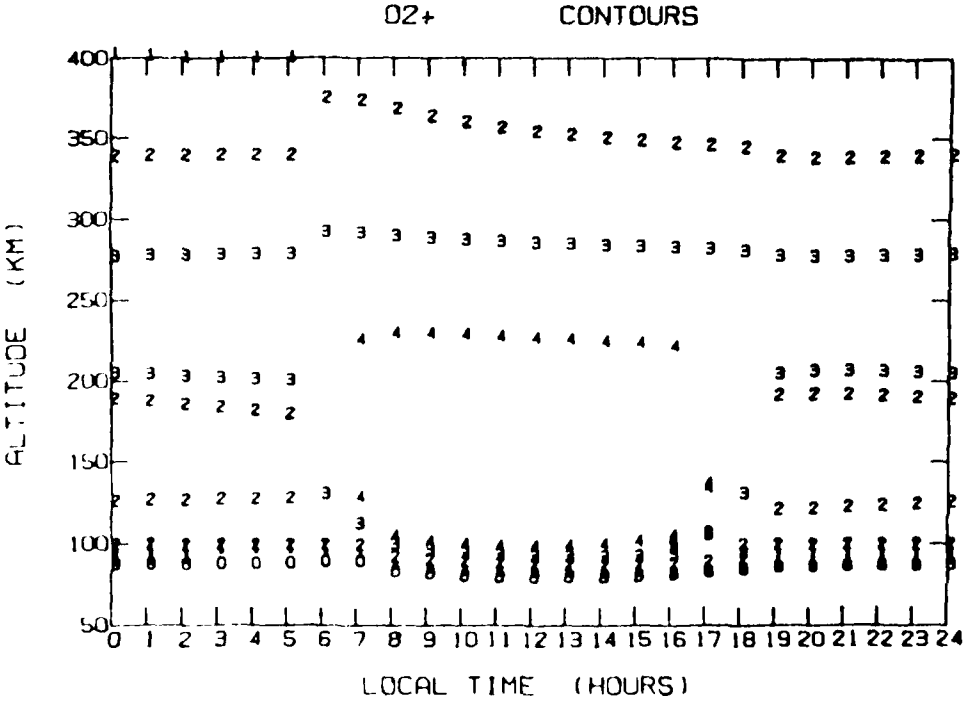

Figure 14. The Iso-Density Contours for O_2^+

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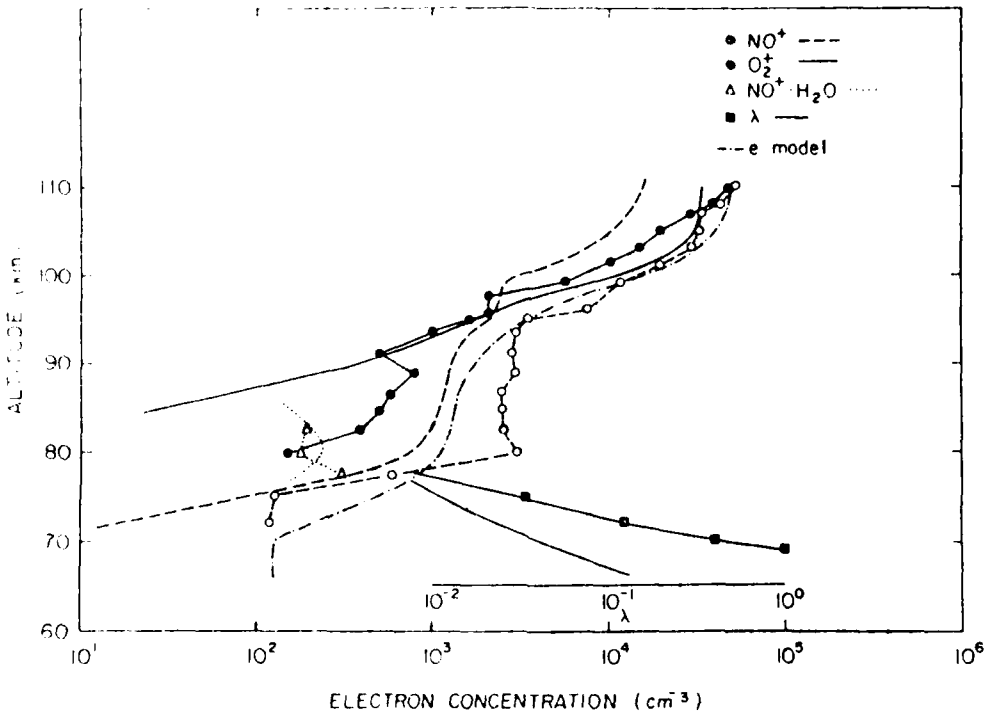

Figure 35. Altitude Profiles of NO_2^+, O^+, $NO^+ \cdot H_2$), Electrons and λ, the Ratio of Negative Ions to Electrons. The curves with symbols are the measurements reported by Torkar and Freidrich.[40] The curves without symbols are from this model

ions than the distribution determined in the Winter Anomaly campaign. However, there is a key reaction in the production of O_2^- in the early part of the negative ion chemistry scheme used by Viggiano et al,[43] namely

$$O_2 + O_2 + e \longrightarrow O_2^- + O_2,$$

They used a rate coefficient of about 1×10^{-29} cm^{-6} sec^{-1} for this reaction. Phelps,[A15] however, cites a rate coefficient of $1.4 \times 10^{-29}(300/T)$ exp $(-600/T)$ for this reaction. This value would result in a theoretical altitude distribution of the negative ions similar to that in our calculations. Therefore, these data of Arnold et al[41] still are unexplained by theory and leave us with D-region negative ions that are still largely not understood.

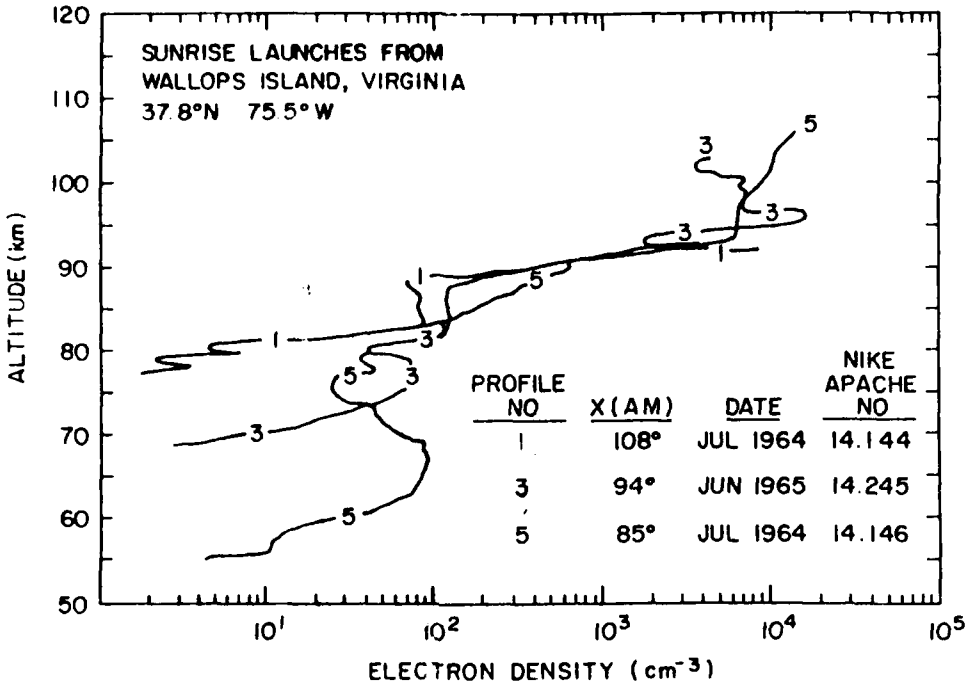

Figure 33. Altitude Profiles of Electron Density From Three Rocket Experiments at Wallops Island by Mechtly and Smith[39]

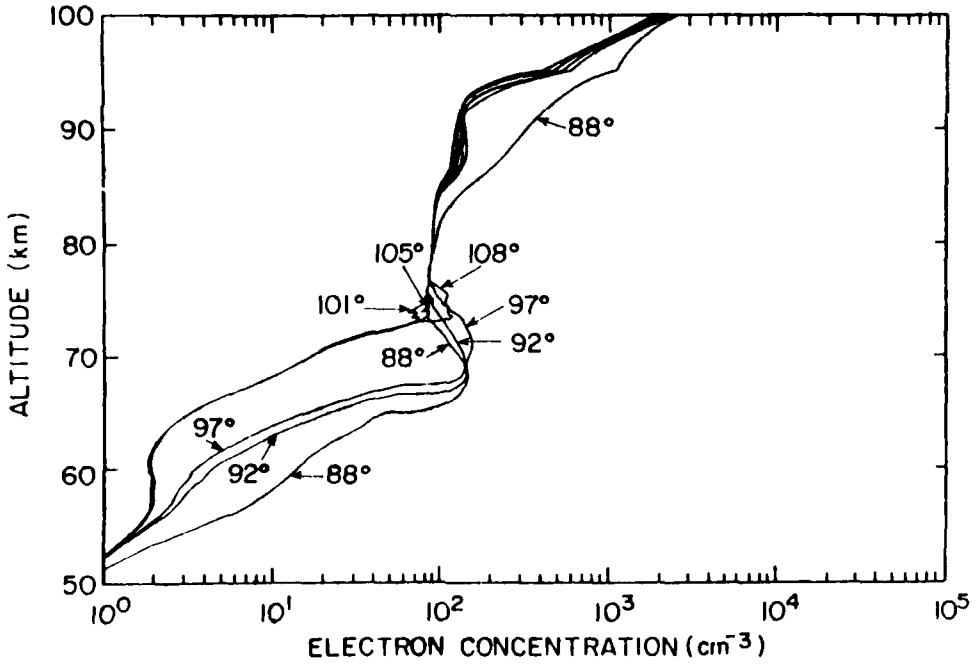

Figure 34. Altitude Profiles of the Electron Concentration From This Model at Several Zenith Angles During Sunrise

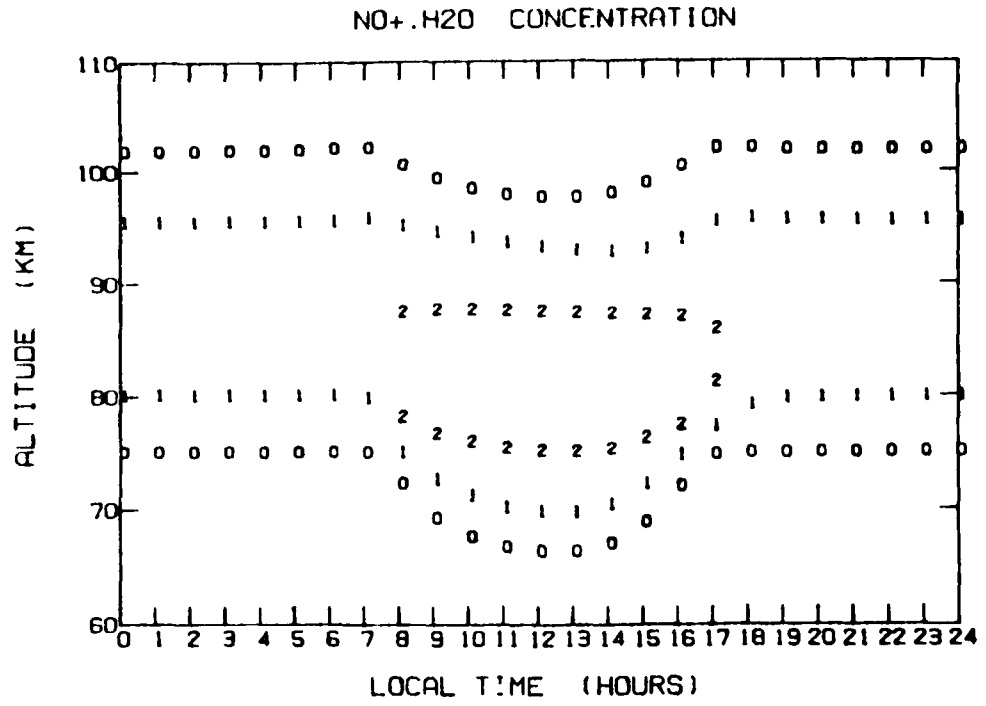

Figure 31. The Iso-Density Contours for $NO^+ \cdot H_2O$ in the Mesosphere

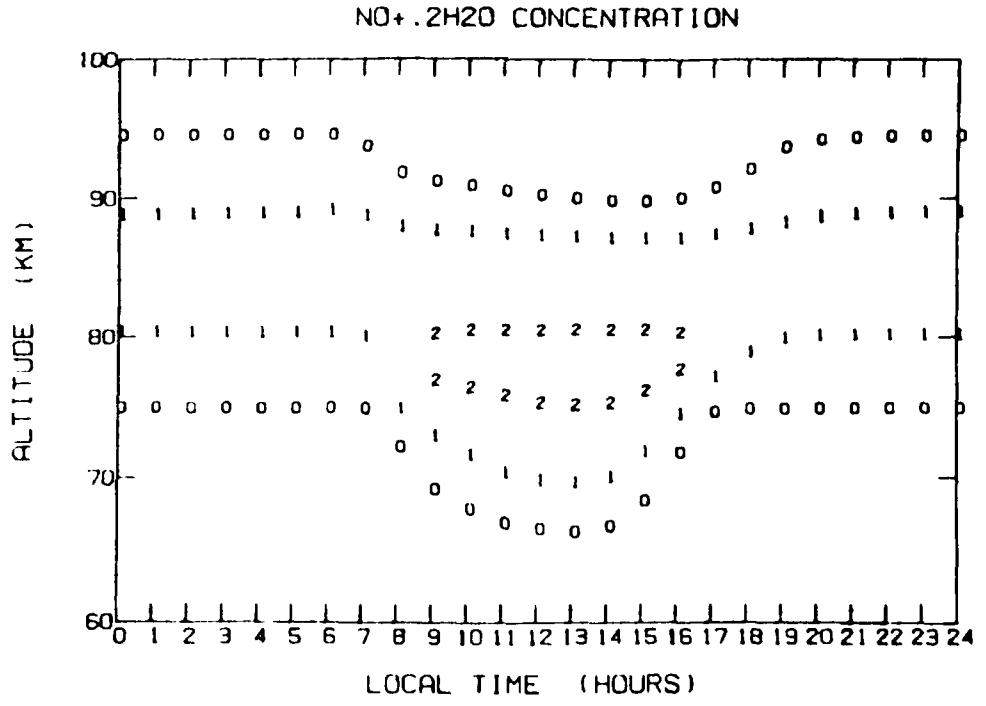

Figure 32. The Iso-Density Contours for $NO^+ \cdot (H_2O)_2$ in the Mesosphere

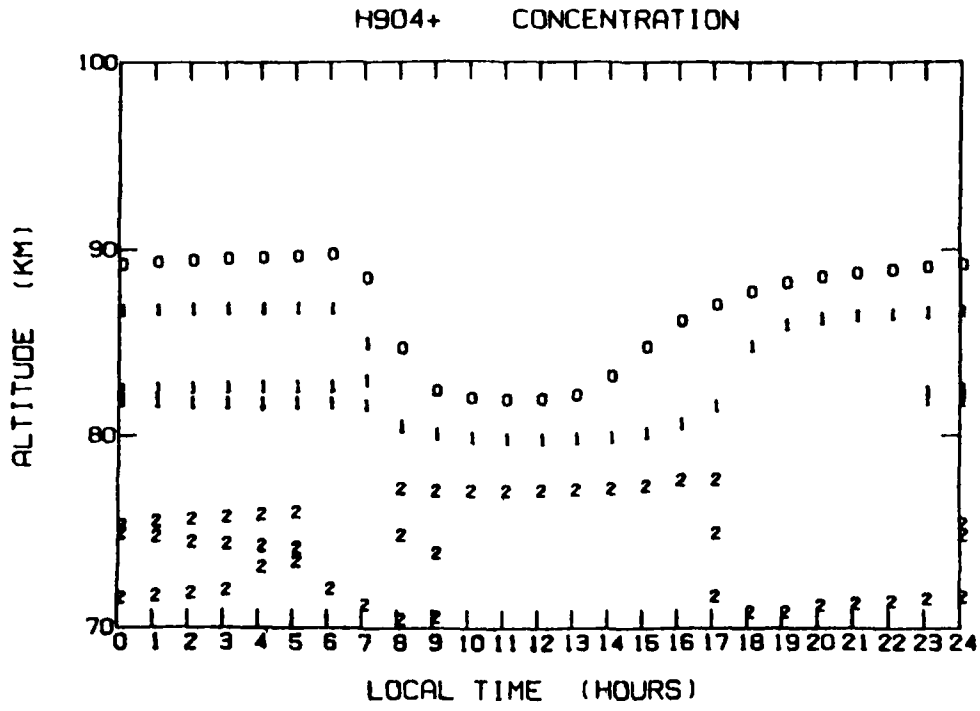

Figure 29. The Iso-Density Contours for $H_9O_4^+$ in the Mesosphere

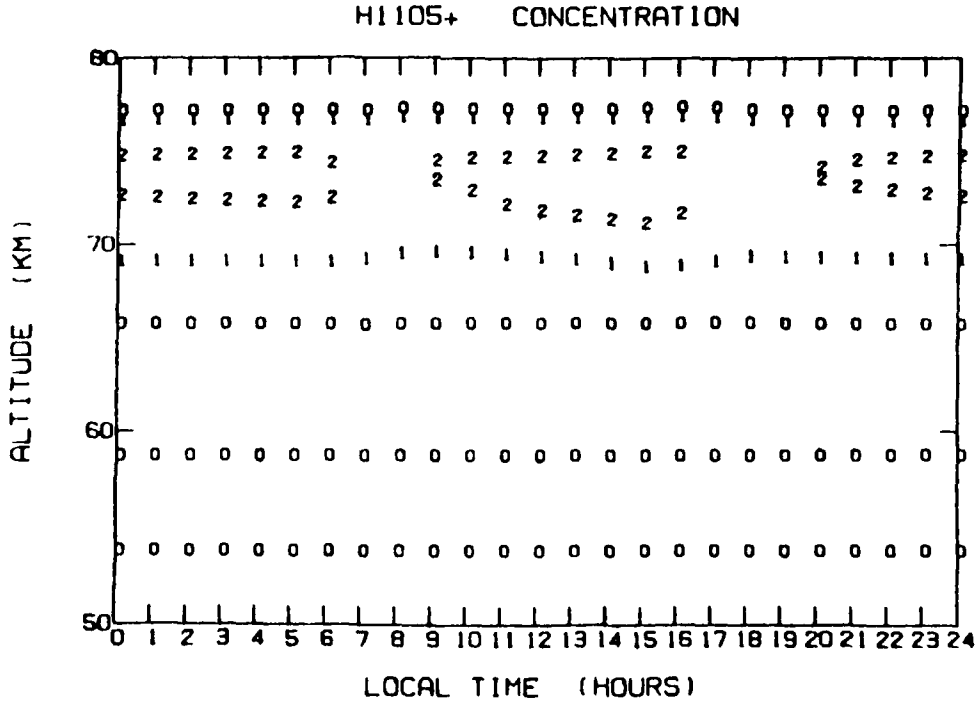

Figure 30. The Iso-Density Contours for $H_{11}O_5^+$ in the Mesosphere

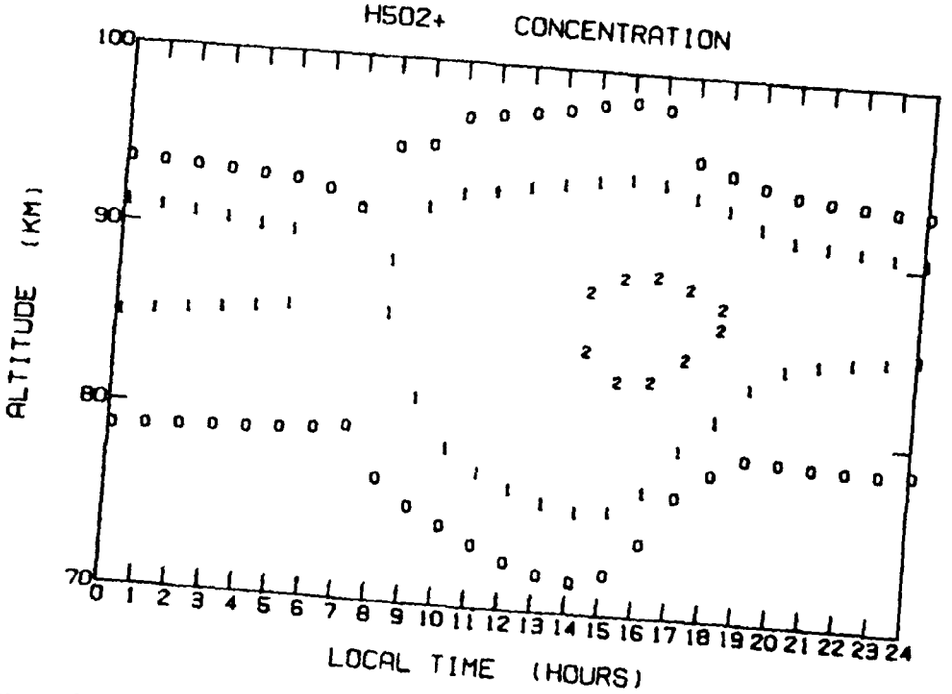

Figure 27. The Iso-Density Contours for $H_5O_2^+$ in the Mesosphere

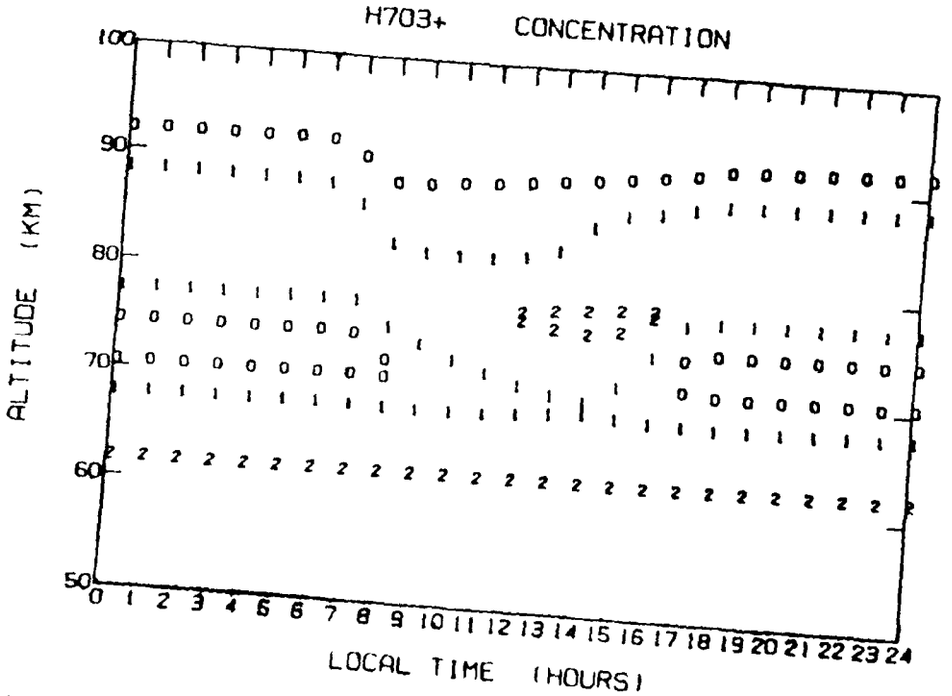

Figure 28. The Iso-Density Contours for $H_7O_3^+$ in the Mesosphere

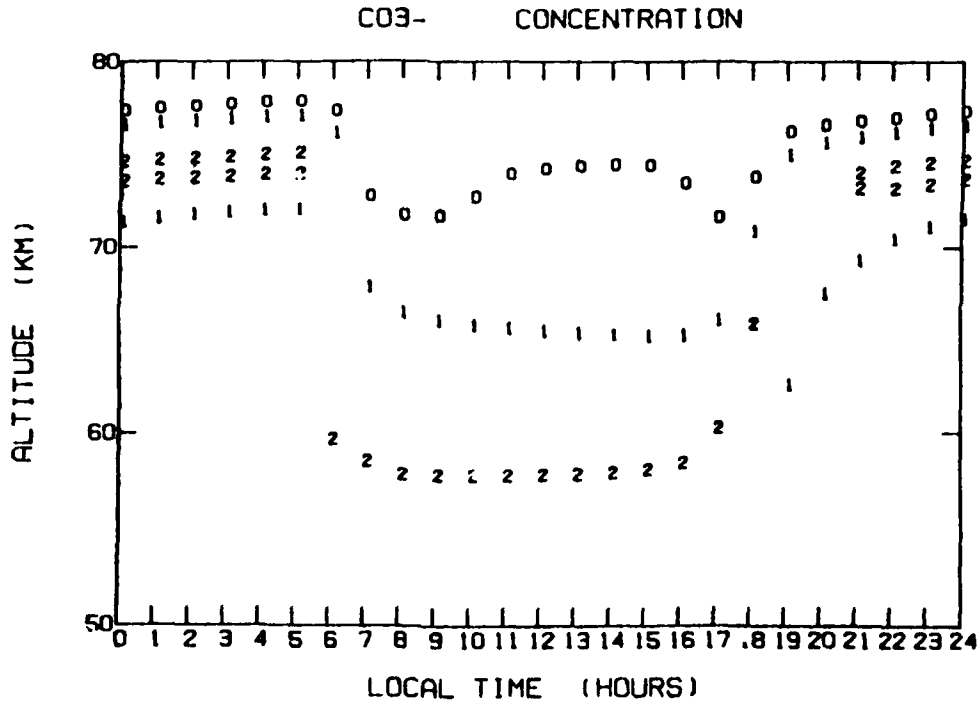

Figure 25. The Iso-Density Contours for CO_3^- in the Mesosphere

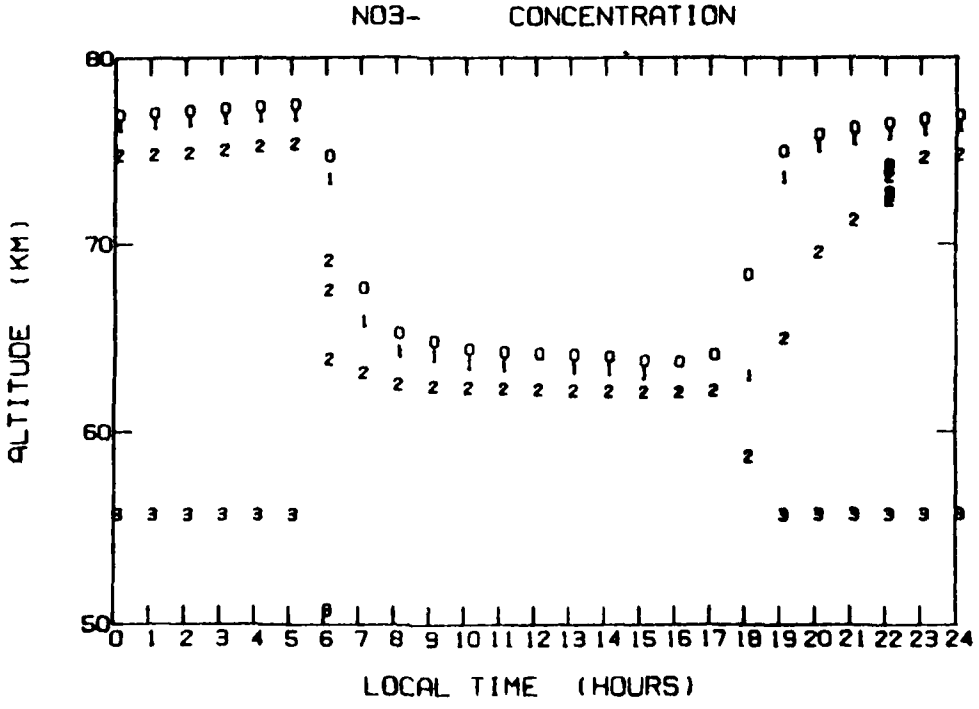

Figure 26. The Iso-Density Contours for NO_3^- in the Mesosphere

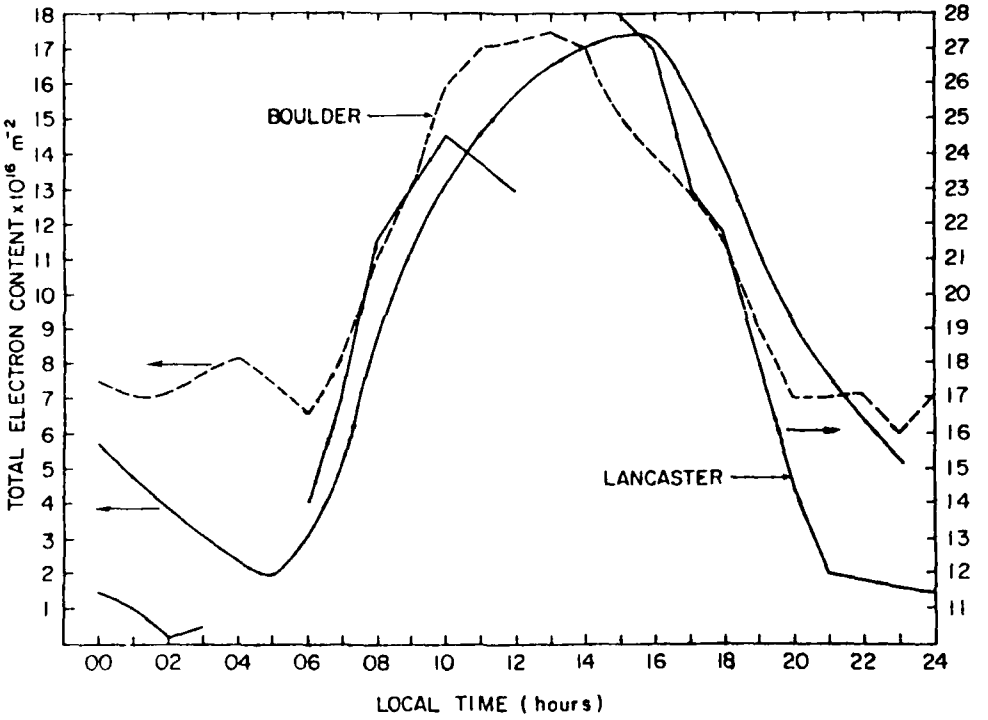

Figure 23. The Total Electron Content. The continuous curve is for this model. The dashed and broken curves are the measurements of Poulter et al.[34]

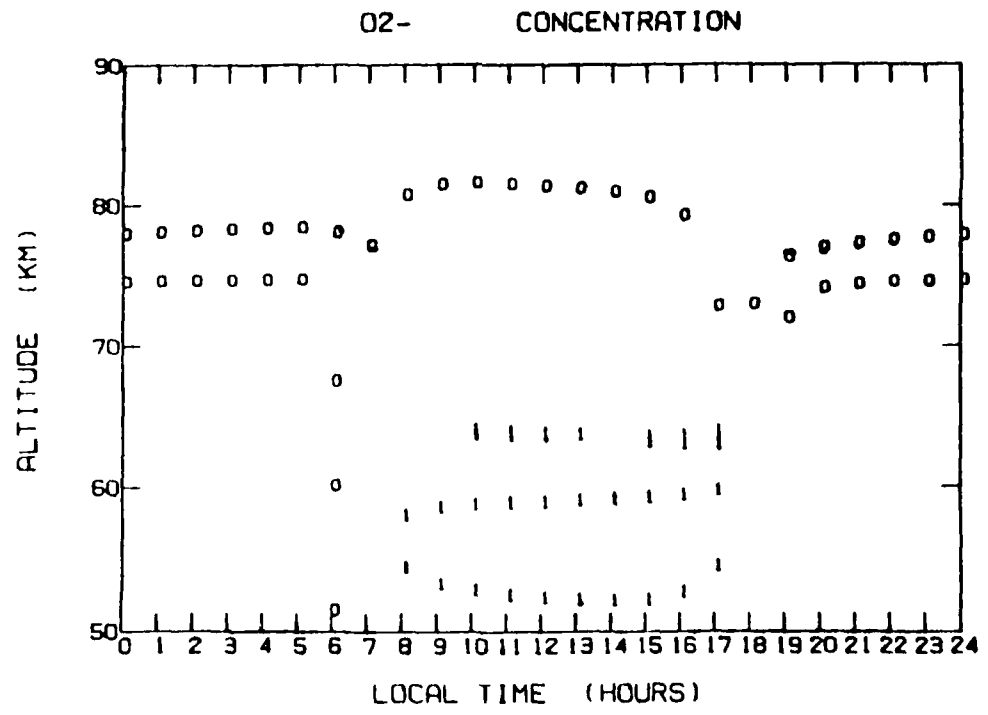

Figure 24. The Iso-Density Contours for O_2^- in the Mesosphere

region (Figure 19) compared to the work of Solomon et al.[38] Below 90 km, the cluster and negative ions change the effective electron density to a point where it disappears completely between 60 and 70 km.

The isodensity contours for the negative ions and the positive water cluster ions for the chemistry given in Appendix A are displayed in Figures 24 to 32. Isodensity plots for the remaining positive and negative mesospheric ions are not presented here because these ions never achieve a concentration greater than $1\,cm^{-3}$ at any time during the diurnal cycle. Of course, the dominant negative ions in the mesosphere are apparently the cluster ions. Because their chemistry is still not fully understood, they have not been included in this work.

Particular emphasis is given to the sunrise period and a comparison of our electron density profiles with sequential measurements made at Wallops Island by Mechtly and Smith.[39] For clarity, the measured profiles are displayed in Figure 33, and our calculated profiles are shown in Figure 34. In some instances, the comparison of theory with experiment is fairly good. Substantial differences, however, do exist. These are, in part, a result of the differences in the seasons (summer for the measurement and winter for the model).

In explaining the D and lower E regions of the ionosphere, there is a question, still not completely answered, of the distribution of the positive and negative ions. To exemplify the puzzle, we cite two works. First, there is the report by Torkar and Freidrich[40] of the measurements taken during the "Winter Anomaly" campaign in Spain. The comparison between our calculations and those measurements, shown in Figure 35, is surprisingly good. In contrast are the measurements of Arnold et al[41] and Viggiano and Arnold.[42] These measurements, supposedly explained by Viggiano et al,[43] show an extremely different distribution of the negative

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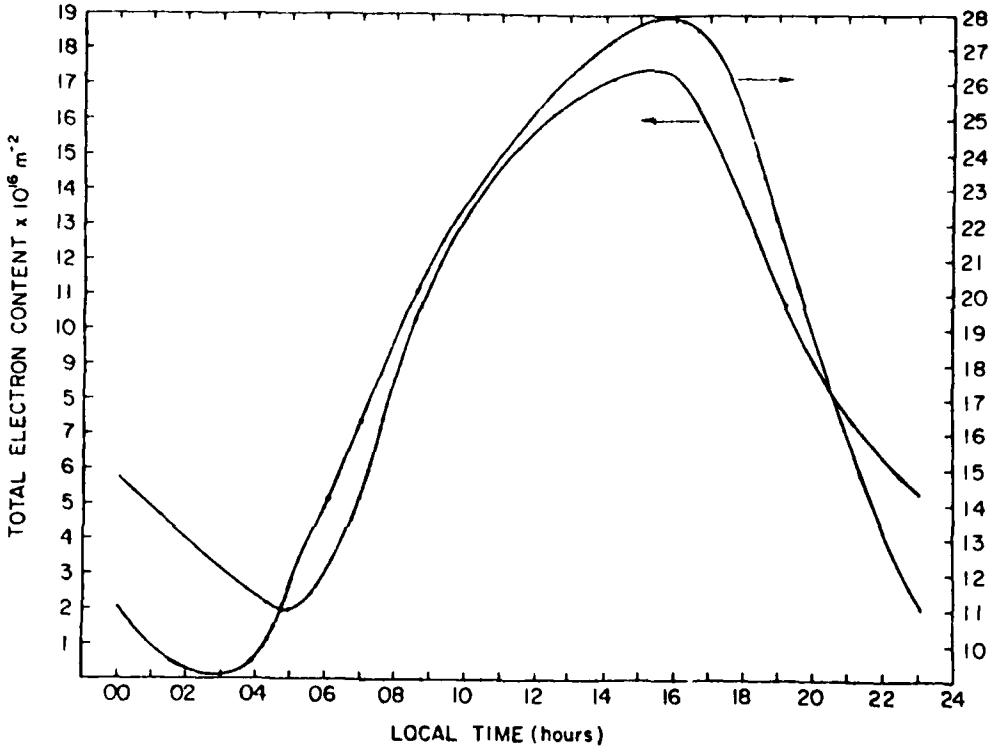

Figure 21. The Total Electron Content. The left-hand scale is for this model. The right-hand scale is for the calculations of Sethia et al[33]

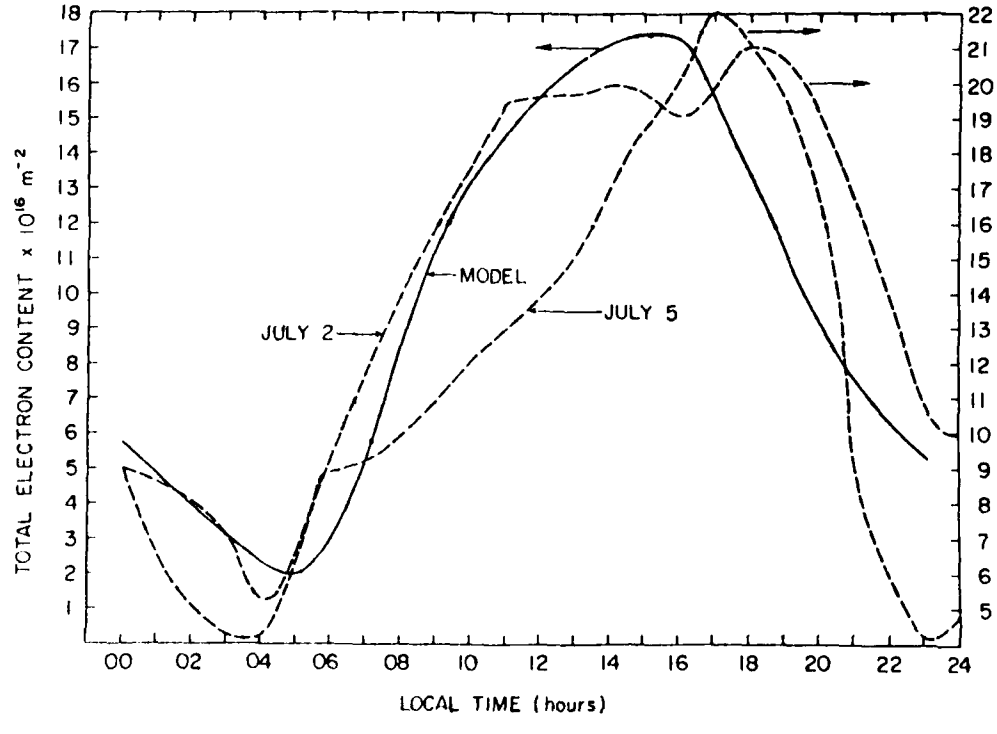

Figure 22. The Total Electron Content. The solid curve is for this model. The dashed curves are the measurements of Sethia et al[33]

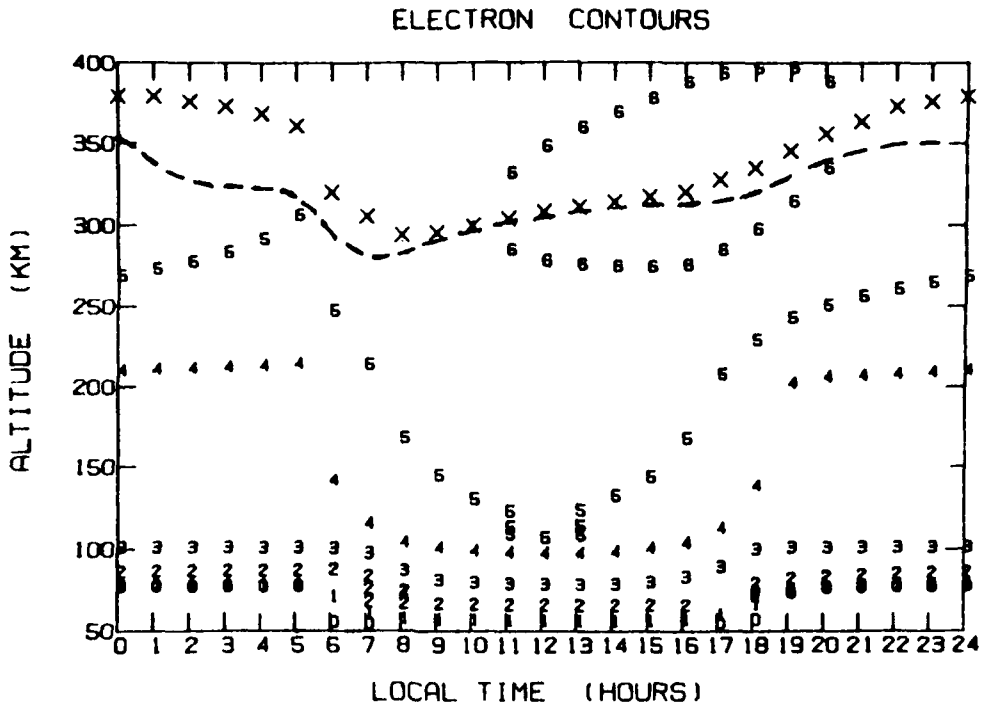

Figure 19. The Iso-Density Contours for the Electrons. The crosses show the diurnal change in the altitude of the peak electron concentration in the model. The dashed curve indicates the measurement of this parameter by Evans[31]

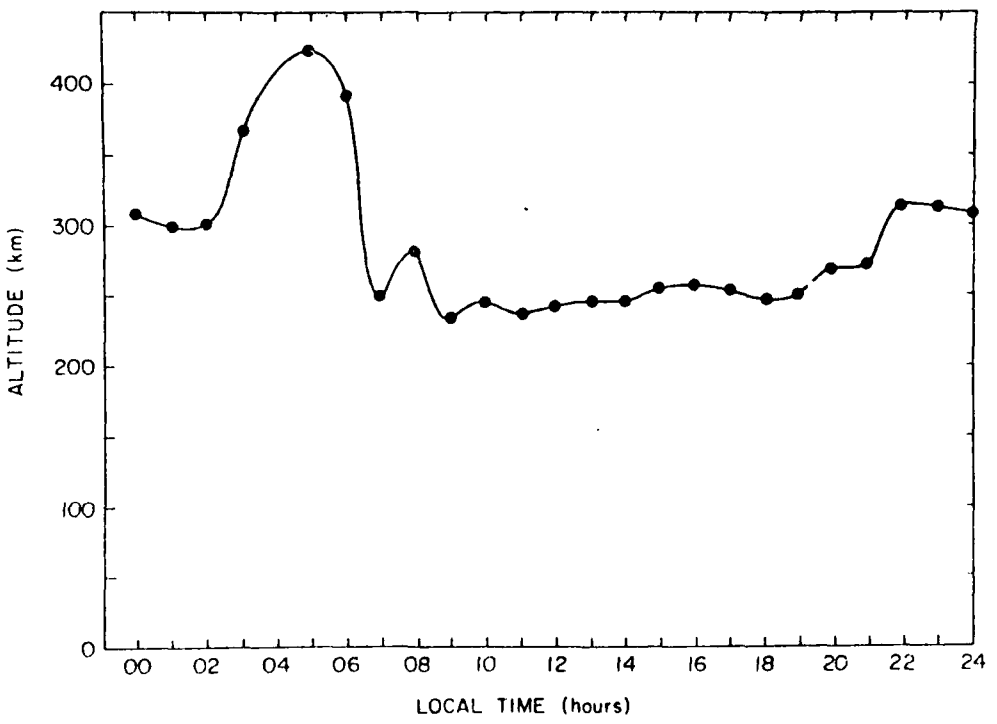

Figure 20. Measurements of Reinisch[32] of the Height of the F-Layer Peak at Eglin AFB, Fla., on 20/21 November 1970

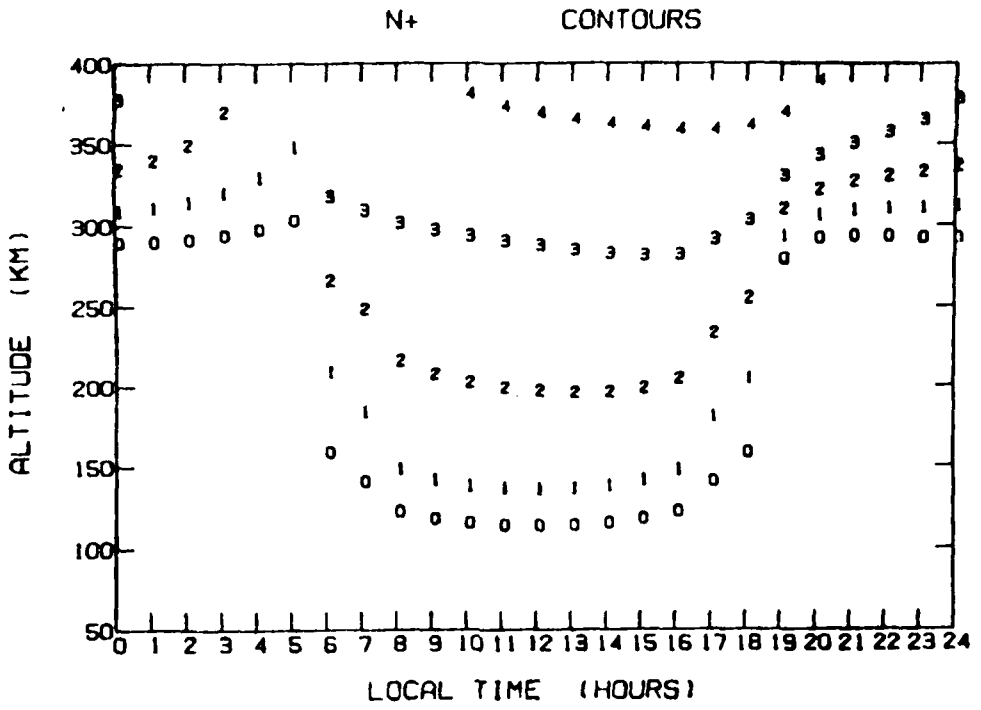

Figure 17. The Iso-Density Contours for N^+

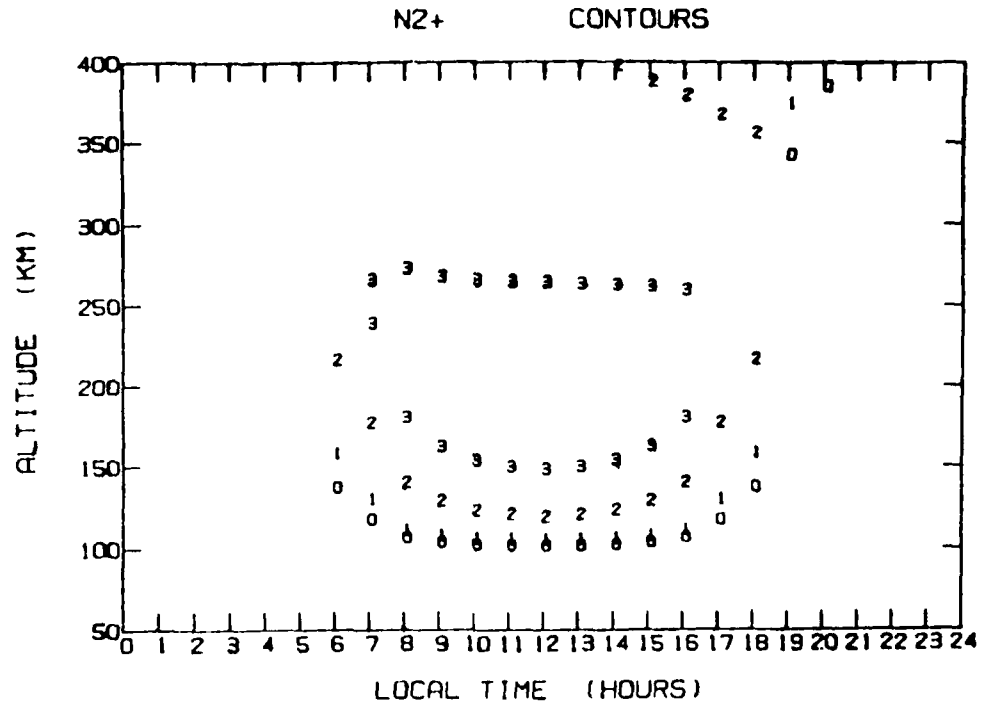

Figure 18. The Iso-Density Contours for N_2^+. At night, the concentration of N_2^+ falls below 1 cm^{-3} at all altitudes

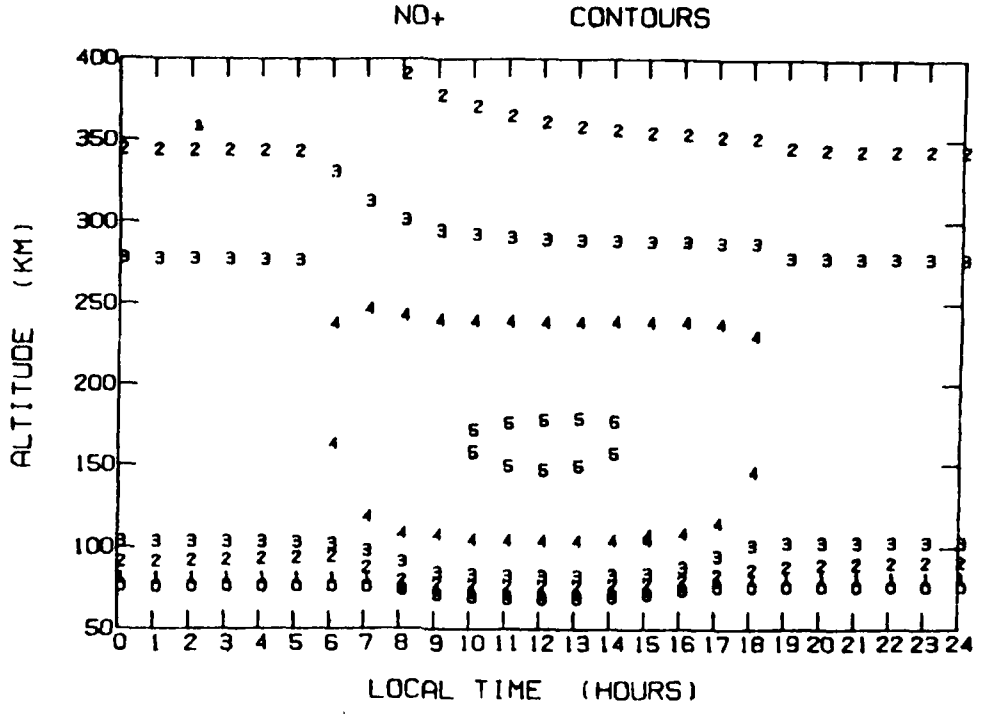

Figure 15. The Iso-Density Contours for NO^+

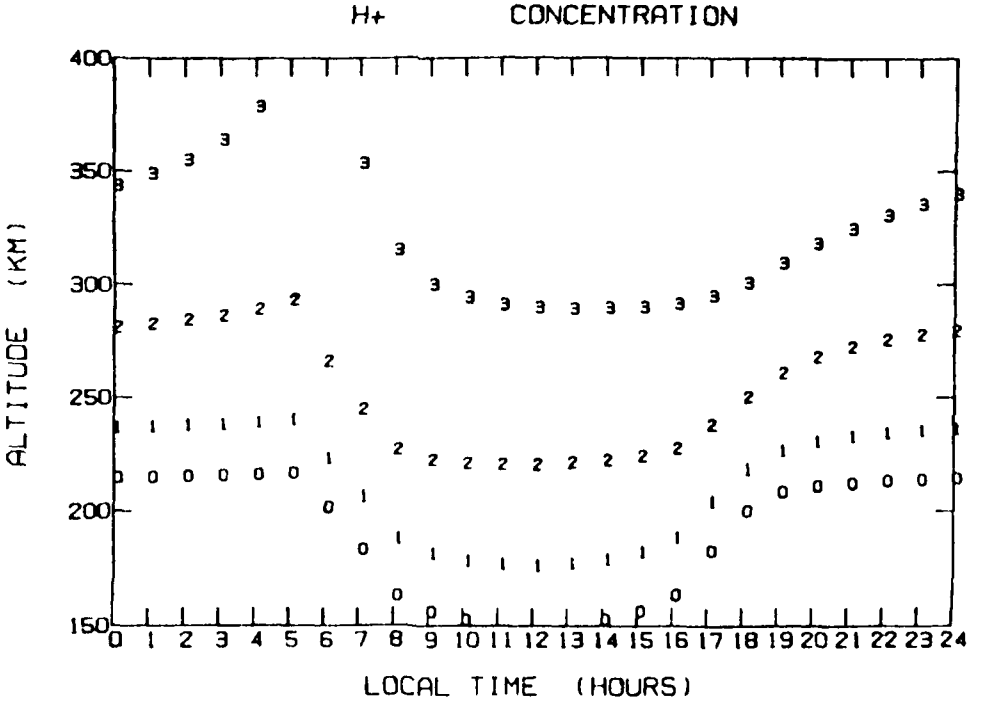

Figure 16. The Iso-Density Contours for H^+

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Appendix A
The Chemical Reactions

Table A1 lists the complete set of chemical reactions used in this report. Reactions 1 through 127 have temperature invariant rate coefficients that are listed after each reaction along with the source from which the rate coefficient was taken. Reactions 128 through 184 are temperature dependent. The rate coefficients for these reactions are of the form

$$k(z) = A \left(\frac{T(z)}{300}\right)^B \exp\left(\frac{C}{T(z)}\right) \qquad (A1)$$

where the A's, B's, and C's are listed in that order after each reaction and T(z) is the temperature at altitude z. Reactions 185 through 207 are the photo-reactions, and are functions of the wavelength of the solar radiation and the local solar flux. Reactions 208 through 215 are the energetic electron processes. Some of the rate coefficients in the list of reactions have not been measured in the laboratory. Therefore, these rate coefficients are given as estimates.

Table A1. Chemical Reaction Scheme

NO.	CHEMICAL REACTION	A	B	C	REFERENCE
1	O + N2O = N + O	1.00E-12	0.00	0.	A1 DAVENPORT ET AL (1976)
2	O + OH = O2 + H	2.20E-11	0.00	0.	A2 BAULCH ET AL (1972)
3	O + HO2 = O2 + OH	1.00E-11	0.00	0.	A3 KAUFMAN (1964)
4	O + NO2 = O2 + NO	9.10E-12	0.00	0.	A4 DAVIS ET AL (1973)
5	H + HO2 = O2 + H2	1.40E-11	0.00	0.	A2 BAULCH ET AL (1972)
6	H + HO2 = OH + OH	1.00E-11	0.00	0.	A3 KAUFMAN (1964)
7	H + O3 = O2 + OH	2.60E-11	0.00	0.	A5 PHILLIPS AND SCHIFF (1962B)
8	N + O3 = O2 + NO	5.70E-13	0.00	0.	A6 PHILLIPS AND SCHIFF (1962A)
9	N + NO2 = N2O + O	8.00E-12	0.00	0.	A7 PHILLIPS AND SCHIFF (1965)
10	N + NO2 = NO + NO	6.00E-12	0.00	0.	A7 PHILLIPS AND SCHIFF (1965)
11	N + NO2 = N2 + O2	4.00E-12	0.00	0.	A7 PHILLIPS AND SCHIFF (1965)
12	OH + OH = O + H2O	2.00E-12	0.00	0.	A5 KAUFMAN (1969)
13	OH + HO2 = O2 + H2O	2.00E-10	0.00	0.	A9 HOCHANADEL ET AL (1972)
14	N2D + O2 = O + NO	6.00E-12	0.00	0.	A10 LIN AND KAUFMAN (1971)
15	O1D + H2O = OH + OH	2.10E-10	0.00	0.	A11 DAVIDSON ET AL (1976)
16	O1D + M = O + M	3.00E-11	0.00	0.	A11 DAVIDSON ET AL (1976)
17	O1D + H2 = H + OH	1.30E-10	0.00	0.	A11 DAVIDSON ET AL (1976)
18	O21D + M = O2 + M	4.40E-19	0.00	0.	A12 CLARK AND WAYNE (1969)
19	O21D = O2	2.58E-04	0.00	0.	A13 BADGER ET AL (1965)
20	HNO2 + O = OH + NO2	1.00E-15	0.00	0.	A14 KAISER AND JAPER (1978)
21	HNO2 + OH = H2O + NO2	6.60E-12	0.00	0.	A15 COX ET AL (1976)
22	N2+ + E = N + N	1.50E-07	0.00	0.	A16 BIONDI (1969)
23	N2+ + E = N2O + N2D	1.50E-07	0.00	0.	A16 BIONDI (1969)
24	H3O+ + E = H2 + OH	1.00E-06	0.00	0.	A17 BIONDI (1973)
25	H5O2+ + E = H2O + H2 + OH	2.00E-06	0.00	0.	A17 BIONDI (1973)
26	H7O3+ + E = 2H2O + H2 + OH	4.00E-06	0.00	0.	A17 BIONDI (1973)
27	H9O4+ + E = 3H2O + H2 + OH	5.00E-06	0.00	0.	A17 BIONDI (1973)
28	H11O5+ + E = 4H2O + H2 + OH	7.50E-06	0.00	0.	ESTIMATED
29	H3O+.OH + E = H2O + OH + H	2.00E-06	0.00	0.	ESTIMATED
30	H5O2+.CO2 + E = 2H2O + CO2 + H	2.00E-06	0.00	0.	ESTIMATED
31	O + E = O-	1.30E-15	0.00	0.	A18 BRANSCOMB (1964)
32	O2 + N2 + E = O2- + N2	1.00E-31	0.00	0.	A19 PHELPS (1969)
33	O2+ + NO = NO+ + O2	6.00E-10	0.00	0.	A20 FERGUSON (1973)
34	O2+ + N = NO+ + O	1.80E-10	0.00	0.	A21 GOLDAN ET AL (1966)
35	O2+ + NO2 = NO2+ + O2	6.60E-10	0.00	0.	A22 FEHSENFELD ET AL (1973)
36	O4+ + O = O2+ + O3	3.00E-10	0.00	0.	A20 FERGUSON (1973)
37	O4+ + H2O = O2+.H2O + O2	1.50E-09	0.00	0.	A23 HOWARD ET AL (1972)
38	N2+ + O = NO+ + N	7.50E-11	0.00	0.	A24 FERGUSON (1974)
39	N2+ + O = NO+ + N2D	7.50E-11	0.00	0.	A24 FERGUSON (1974)
40	O+ + H = H+ + O	6.00E-10	0.00	0.	A24 FERGUSON (1974)
41	H+ + O = O+ + H	4.00E-10	0.00	0.	A24 FERGUSON (1974)
42	N+ + O2 = NO+ + O	6.00E-10	0.00	0.	A25 DUNKIN ET AL (1968)
43	N+ + O2 = O2+ + N	6.00E-10	0.00	0.	A25 DUNKIN ET AL (1968)
44	N+ + O2 = O2+ + N2D	2.00E-10	0.00	0.	A24 FERGUSON (1974)
45	HE+ + O2 = O+ + O + HE	1.50E-09	0.00	0.	A24 FERGUSON (1974)
46	HE+ + O2 = O2+ + HE	2.00E-10	0.00	0.	A24 FERGUSON (1974)
47	HE+ + N2 = N+ + N + HE	1.50E-09	0.00	0.	A24 FERGUSON (1974)

Table A1. Chemical Reaction Scheme (Contd)

NO.	CHEMICAL REACTION	A	B	C	REFERENCE
48	HE+ + N2 = N2+ + HE	3.50E-10	0.00	0.	A24 FERGUSON (1974)
49	HE+ + NO = N+ + O + HE	1.50E-09	0.00	0.	A26 FEHSENFELD ET AL (1966)
50	NO2+ + NO = NO+ + NO2	2.90E-10	0.00	0.	A26 FEHSENFELD ET AL (1969A)
51	H5O2+ + CO2 + M = H5O2+.CO2+ M	3.00E-30	0.00	0.	ESTIMATED
52	H9O4+ + H2O + M = H11O5+ + M	1.00E-27	0.00	0.	ESTIMATED
53	O2+.H2O + H2O = H3O+.OH + O2	1.00E-09	0.00	0.	A23 HOWARD ET AL (1972)
54	O2+.H2O + H2O = H3O+ + OH + O2	2.00E-10	0.00	0.	A23 HOWARD ET AL (1972)
55	NO+.3H2O + H2O = H7O3+ + HNO2	7.00E-11	0.00	0.	A25 PUCKETT AND TEAGUE (1971)
56	NO+.CO2 + H2O = NO+.H2O + CO2	1.00E-09	0.00	0.	A29 DUNKIN ET AL (1971)
57	H3O+.N2 + CO2 = H3O+.CO2 + N2	1.00E-10	0.00	0.	ESTIMATED
58	H3O+.CO2 + H2O + N2 = H5O2+.CO2+ N2	1.00E-27	0.00	0.	ESTIMATED
59	H5O2+.CO2+ H2O = H7O3+ + CO2	1.00E-10	0.00	0.	ESTIMATED
60	H3O+.CO2 + H2O = H5O2+ + CO2	1.00E-10	0.00	0.	ESTIMATED
61	H3O+.OH + H2O = H5O2+ + OH	1.40E-09	0.00	0.	A23 HOWARD ET AL (1972)
62	H3O+ + NO2- = H2O + NO2 + H	6.00E-08	0.00	0.	ESTIMATED
63	H3O+ + NO3- = H2O + NO2 + OH	6.00E-08	0.00	0.	ESTIMATED
64	H3O+ + CO3- = H2O + CO2 + OH	6.00E-08	0.00	0.	ESTIMATED
65	H5O2+ + O2- = H2O + H2O + HO2	6.00E-08	0.00	0.	ESTIMATED
66	H5O2+ + NO2- = 2H2O + NO2 + H	6.00E-08	0.00	0.	ESTIMATED
67	H5O2+ + NO3- = 2H2O + NO2 + OH	6.00E-08	0.00	0.	ESTIMATED
68	H5O2+ + CO3- = 2H2O + CO2 + OH	6.00E-08	0.00	0.	ESTIMATED
69	H5O2+ + CO4- = 2H2O + CO2 + HO2	6.00E-08	0.00	0.	ESTIMATED
70	H7O3+ + NO2- = 3H2O + NO2 + H	6.00E-08	0.00	0.	ESTIMATED
71	H7O3+ + NO3- = 3H2O + NO2 + OH	6.00E-08	0.00	0.	ESTIMATED
72	H7O3+ + CO3- = 3H2O + CO2 + OH	6.00E-08	0.00	0.	ESTIMATED
73	H7O3+ + CO4- = 3H2O + CO2 + HO2	6.00E-08	0.00	0.	ESTIMATED
74	H9O4+ + NO2- = 4H2O + NO2 + H	6.00E-08	0.00	0.	ESTIMATED
75	H9O4+ + NO3- = 4H2O + NO2 + OH	6.00E-08	0.00	0.	ESTIMATED
76	H9O4+ + CO3- = 4H2O + CO2 + OH	6.00E-08	0.00	0.	ESTIMATED
77	H9O4+ + CO4- = 4H2O + CO2 + HO2	6.00E-08	0.00	0.	ESTIMATED
78	H11O5+ + NO2- = 5H2O + NO2 + H	6.00E-08	0.00	0.	ESTIMATED
79	H11O5+ + NO3- = 5H2O + NO2 + OH	6.00E-08	0.00	0.	ESTIMATED
80	H11O5+ + CO3- = 5H2O + CO2 + OH	6.00E-08	0.00	0.	ESTIMATED
81	H11O5+ + CO4- = 5H2O + CO2 + HO2	6.00E-08	0.00	0.	ESTIMATED
82	NO+.H2O + NO2- = H2O + NO2 + NO	6.00E-08	0.00	0.	ESTIMATED
83	NO+.H2O + NO3- = H2O + NO2 + NO2	6.00E-08	0.00	0.	ESTIMATED
84	NO+.H2O + CO3- = H2O + NO2 + CO2	6.00E-08	0.00	0.	ESTIMATED
85	NO+.2H2O + NO2- = 2H2O + NO2 + NO	6.00E-08	0.00	0.	ESTIMATED
86	NO+.2H2O + NO3- = 2H2O + NO2 + NO2	6.00E-08	0.00	0.	ESTIMATED
87	NO+.2H2O + CO3- = 2H2O + NO2 + CO2	6.00E-08	0.00	0.	ESTIMATED
88	NO+.3H2O + NO2- = 3H2O + NO2 + NO	6.00E-08	0.00	0.	ESTIMATED
89	NO+.3H2O + NO3- = 3H2O + NO2 + NO2	6.00E-08	0.00	0.	ESTIMATED
90	NO+.3H2O + CO3- = 3H2O + NO2 + CO2	6.00E-08	0.00	0.	ESTIMATED
91	H3O+.CO2 + NO3- = H2O2 + HNO2 + CO2	6.00E-08	0.00	0.	ESTIMATED
92	H3O+.CO2 + CO3- = 2CO2 + H2O + OH	6.00E-08	0.00	0.	ESTIMATED
93	H3O+.CO2 + CO4- = 2CO2 + H2O + HO2	6.00E-08	0.00	0.	ESTIMATED
94	H5O2+.CO2+ CO3- = 2CO2 + 2H2O + OH	6.00E-08	0.00	0.	ESTIMATED

Table A1. Chemical Reaction Scheme (Contd)

NO.	CHEMICAL REACTION	A	B	C	REFERENCE
95	HO2+.CO2+ CO4- = 2CO2 + 2H2O + HO2	6.00E-08	0.00	0.	ESTIMATED
96	O- + HV = O + E	1.40E+00	0.00	0.	A30 BRANSCOMB ET AL (1958)
97	O- + O = O2 + E	2.00E-10	0.00	0.	A31 FEHSENFELD ET AL (1967)
98	O- + O3 = O3- + O	5.30E-10	0.00	0.	A31 FEHSENFELD ET AL (1967)
99	O2- + HV = O2 + E	3.30E-01	0.00	0.	A32 WOD ET AL (1969)
100	O2- + O = O3 + E	1.50E-10	0.00	0.	A33 FEHSENFELD ET AL (1969C)
101	O2- + O = O- + O2	1.50E-10	0.00	0.	A34 BORTNER AND BAURER 1979)
102	O2- + O3 = O3- + O2	4.00E-10	0.00	0.	A31 FEHSENFELD ET AL (1967B)
103	O2- + O21D = O2 + O2 + E	2.00E-10	0.00	0.	A31 FEHSENFELD ET AL (1969C)
104	O3- + HV = O3 + E	7.00E-02	0.00	0.	A35 WONG ET AL (1972)
105	O3- + HV = O- + O2	5.00E-01	0.00	0.	A36 PETERSON (1976)
106	O3- + O = O2- + O2	3.20E-10	0.00	0.	A34 BORTNER AND BAURER (1979)
107	O4- + O = O3- + O2	3.00E-10	0.00	0.	A37 FEHSENFELD ET AL (1969B)
108	O4- + O = O- + O2 + O2	1.00E-10	0.00	0.	A37 FEHSENFELD ET AL (1969B)
109	O4- + CO2 = CO4- + O2	4.30E-10	0.00	0.	A38 ADAMS ET AL (1970)
110	CO3- + HV = O- + CO2	2.00E-01	0.00	0.	A36 PETERSON (1976)
111	CO3- + O = O2- + CO2	8.00E-11	0.00	0.	A24 FERGUSON (1974)
112	CO3- + NO2 = NO3- + CO2	2.00E-10	0.00	0.	A39 FEHSENFELD AND FERGUSON (1974)
113	CO4- + HV = O2- + CO2	1.40E-02	0.00	0.	A34 BORTNER AND BAURER (1979)
114	CO4- + HV = O2 + CO2 + E	3.00E-01	0.00	0.	A35 WONG ET AL (1972)
115	CO4- + O = CO3- + O2	1.50E-10	0.00	0.	A37 FEHSENFELD ET AL (1969B)
116	CO4- + O3 = O3- + CO2 + O2	1.30E-10	0.00	0.	A39 FEHSENFELD AND FERGUSON (1974)
117	CO4- + NO = NO3- + CO2	4.80E-11	0.00	0.	A37 FEHSENFELD ET AL (1969B)
118	NO2- + HV = NO2 + E	3.00E-02	0.00	0.	A34 BORTNER AND BAURER (1979)
119	NO2- + O3 = NO3- + O2	1.80E-11	0.00	0.	A40 FEHSENFELD AND FERGUSON (1968)
120	NO3- + HV = NO2- + O	3.00E-02	0.00	0.	A34 BORTNER AND BAURER (1979)
121	NO3- + O = NO2- + O2	1.00E-12	0.00	0.	A37 FEHSENFELD ET AL (1969B)
122	NO3 + NO = NO2 + NO2	2.00E-11	0.00	0.	A41 GRAHAM AND JOHNSTON (1978)
123	NO3- + HV = NO3 + E	2.00E-02	0.00	0.	A34 BORTNER AND BAURER (1979)
124	O- + O3 = O2- + O2	4.40E-10	0.00	0.	A34 BORTNER AND BAURER (1976)
125	O+(2D) + N2 = N2+ + O	3.00E-10	0.00	0.	A42 STEBBINGS ET AL (1966)
126	O+(2D) + O2 = O2+ + O	3.00E-10	0.00	0.	A42 STEBBINGS ET AL (1966)
127	O+ + CO2 = O2+ + CO	1.00E-09	0.00	0.	A43 LINDBERGER ET AL (1974)
128	O + O + M = O2 + M	4.80E-33	-2.00	0.	A44 CAMPBELL AND GRAY (1973)
129	O + O2 + M = O3 + M	5.50E-34	-2.60	0.	A45 KAUFMAN AND KELSO (1964)
130	O + O3 = O2 + O2	1.20E-11	0.00	-2.00E+03	A46 SCHIFF (1969)
131	O + H2 = OH + H	7.00E-11	0.00	-5.10E+03	A47 WONG AND POTTER (1965)
132	O + H2O2 = OH + HO2	1.20E-12	0.00	-2.20E+03	A48 DAVIS ET AL (1974A)
133	O + H2O2 = O2 + H2O	1.80E-12	0.00	-2.20E+03	A48 DAVIS ET AL (1974A)
134	H + H2O2 = H2 + HO2	2.30E-12	0.00	-1.40E+03	A49 KLEMM ET AL (1975)
135	H + H2O2 = OH + H2O	2.90E-12	0.00	-1.40E+03	A49 KLEMM ET AL (1975)
136	H + O2 + M = HO2 + M	4.40E-33	0.00	5.00E+02	A2 BAULCH ET AL (1972)
137	N + O2 = O + NO	5.50E-12	0.00	-3.22E+03	A50 BECKER ET AL (1969)
138	N + NO = O + N2	8.20E-11	0.00	-4.10E+02	A51 CLYNE AND MCDERMID (1975)
139	N + O + M = NO + M	1.80E-31	-.50	0.	A52 BAULCH ET AL (1973)
140	OH + O3 = O2 + HO2	1.30E-12	0.00	-9.50E+02	A53 ANDERSON AND KAUFMAN (1973)
141	OH + H2O2 = HO2 + H2O	1.00E-11	0.00	-7.50E+02	A34 BORTNER AND BAURER (1979)

Table A1. Chemical Reaction Scheme (Contd)

NO.	CHEMICAL REACTION	A	B	C		REFERENCE
142	NO + O3 = O2 + NO2	1.70E-12	0.00	-1.31E+03	A52	BAULCH ET AL (1973)
143	NO + O + M = NO2 + M	1.55E-32	0.00	-5.84E+02	A57	WHYTLOCK ET AL (1976)
144	HO2 + HO2 = O2 + H2O2	7.55E-12	0.00	-5.00E+02	A34	BORTNER AND BAURER (1979)
145	HO2 + O3 = O2 + O2 + OH	1.00E-13	0.00	-1.25E+03	A53	GARVIN (1973)
146	NO2 + H = NO + OH	4.80E-10	0.00	-4.00E+02	A52	CLYNE AND MONKHOUSE (1977)
147	CO + OH = H + CO2	2.20E-13	0.00	-8.00E+01	A57	DAVIS ET AL (1974B)
148	CO + O + M = CO2 + M	6.50E-33	0.00	-2.18E+03	A58	BAULCH ET AL (1976)
149	N2D + E = N + E	3.20E-10	.80	0.	A34	BORTNER AND BAURER (1979)
150	NO+ + E = N + O	2.00E-07	-1.00	0.	A17	BIONDI (1973)
151	NO+ + E = N2D + O	2.00E-07	-1.00	0.	A17	BIONDI (1973)
152	O2+ + E = O + O	2.00E-07	-1.00	0.	A17	BIONDI (1973)
153	O+ + E = O + HV	3.50E-12	-.70	0.	A34	BORTNER AND BAURER (1979)
154	N+ + E = N + HV	3.50E-12	-.70	0.	A34	BORTNER AND BAURER (1979)
155	H+ + E = H + HV	3.50E-12	-.70	0.	A34	BORTNER AND BAURER (1979)
156	NO2+ + E = NO + O	3.00E-07	-.50	0.	A34	BORTNER AND BAURER (1979)
157	NO+.H2O + E = H2O + NO	1.50E-06	-.20	0.	A34	BORTNER AND BAURER (1979)
158	NO+.2H2O + E = H2O + H2O + NO	2.00E-06	-.20	0.	A34	BORTNER AND BAURER (1979)
159	NO+.3H2O + E = 3H2O + NO	3.00E-06	-.20	0.	A34	BORTNER AND BAURER (1979)
160	O2 + O2 + E = O2- + O2	1.40E-29	-1.00	-6.00E+02	A19	PHELPS (1969)
161	O3 + E = O- + O2	9.00E-12	1.50	0.	A55	STELMAN ET AL (1972)
162	O2+ + O2 + M = O4+ + M	3.90E-30	-3.20	0.	A6C	PAYZANT ET AL (1973)
163	O4+ + M = O2+ + O2 + M	2.00E-05	-3.20	-5.40E+03	A34	BORTNER AND BAURER (1979)
164	O4+ + O21D = O2+ + O2 + O2	2.00E-05	-3.20	-5.40E+03	A34	BORTNER AND BAURER (1979)
165	NO+ + CO2 + N2 = NO+.CO2 + N2	3.00E-29	-2.00	0.	A34	BORTNER AND BAURER (1979)
166	NO+ + H2O + M = NO+.H2O + M	1.50E-28	-2.00	0.	A34	BORTNER AND BAURER (1979)
167	N2+ + O2 = O2+ + N2	5.00E-11	-.80	0.	A43	LINDBERGER ET AL (1974)
168	O+ + N2 = NO+ + N	1.20E-12	-.50	0.	A43	LINDBERGER ET AL (1974)
169	O+ + O2 = O2+ + O	2.00E-11	-.40	0.	A43	LINDBERGER ET AL (1974)
170	H3O+ + H2O + M = H5O2+ + M	3.50E-27	-4.00	0.	A6W	GOOD ET AL (1970)
171	H3O+ + N2 + N2 = H3O+.N2 + N2	1.40E-30	-2.00	0.	A34	BORTNER AND BAURER (1979)
172	H5O2+ + H2O + M = H7O3+ + M	2.20E-27	-2.80	0.	A34	BORTNER AND BAURER (1979)
173	H7O3+ + H2O + M = H9O4+ + M	2.30E-27	-2.80	0.	A34	BORTNER AND BAURER (1979)
174	H7O3+ + M = H5O2+ + H2O + M	2.50E-03	-4.00	-1.00E+04	A34	BORTNER AND BAURER (1979)
175	H9O4+ + M = H7O3+ + H2O + M	1.20E-01	-4.00	-8.80E+03	A34	BORTNER AND BAURER (1979)
176	H11O5+ + M = H9O4+ + H2O + M	4.00E-01	0.00	-7.67E+03	A34	BORTNER AND BAURER (1979)
177	NO+.H2O + H2O + M = NO+.2H2O + M	1.10E-27	-4.70	0.	A62	HOWARD ET AL (1971)
178	NO+.2H2O + H2O + M = NO+.3H2O + M	1.10E-27	-4.70	0.	A62	HOWARD ET AL (1971)
179	O- + O2 + O2 = O3- + O2	1.10E-30	-1.00	0.	A34	BORTNER AND BAURER (1979)
180	O2- + O2 + O2 = O4- + O2	3.50E-31	-1.00	0.	A34	BORTNER AND BAURER (1979)
181	O2- + O2 + CO2 = CO4- + O2	2.00E-29	-1.00	0.	A34	BORTNER AND BAURER (1979)
182	O3- + CO2 = CO3- + O2	5.50E-10	-.49	0.	A34	BORTNER AND BAURER (1979)
183	O4- + M = O2- + O2 + M	2.00E-05	-1.00	-6.30E+03	A34	BORTNER AND BAURER (1979)
184	CO3- + NO = NO2- + CO2	1.10E-11	-1.10	0.	A34	BORTNER AND BAURER (1979)
185	O + HV = O+ + E	0.	0.00	0.		Wavelength Dependent (See Text)
186	O2 + HV = O2+ + E	0.	0.00	0.		
187	N2 + HV = N2+ + E	0.	0.00	0.		
188	NO + HV = NO+ + E	0.	0.00	0.		

Table A1. Chemical Reaction Scheme (Contd)

NO.	CHEMICAL REACTION	A	B	C	REFERENCE
189	N + HV = N+ + E	0.	0.00	0.	
190	H + HV = H+ + E	0.	0.00	0.	
191	HE + HV = HE+ + E	0.	0.00	0.	
192	O2 + HV = O + O	0.	0.00	0.	
193	O2 + HV = O1D + O	0.	0.00	0.	
194	O3 + HV = O2 + O	0.	0.00	0.	
195	O3 + HV = $O2_{1}D$ + O1D	0.	0.00	0.	
196	H2O + HV = OH + H	0.	0.00	0.	
197	H2O2 + HV = OH + OH	0.	0.00	0.	
198	HO2 + HV = O2 + H	0.	0.00	0.	
199	NO + HV = N + O	0.	0.00	0.	
200	NO2 + HV = NO + O1D	0.	0.00	0.	
201	N2O + HV = N2 + O1D	0.	0.00	0.	
202	HNO2 + HV = OH + NO	0.	0.00	0.	
203	CO2 + HV = CO + O1D	0.	0.00	0.	
204	CO2 + HV = CO + O	0.	0.00	0.	
205	NO3 + HV = NO + O2	0.	0.00	0.	
206	O + HV = O+(2D) + E	0.	0.00	0.	
207	O21D + HV = O2+ + E	0.	0.00	0.	
208	E* + N2 = N + N+ + 2E	0.	0.00	0.	
209	E* + O2 = O + O+ + 2E	0.	0.00	0.	
210	E* + O2 = O + O+(2D) + 2E	0.	0.00	0.	
211	E* + O = O+ + 2E	0.	0.00	0.	
212	E* + O = O+(2D) + 2E	0.	0.00	0.	
213	E* + N2 = N2+ + 2E	0.	0.00	0.	
214	E* + O2 = O2+ + 2E	0.	0.00	0.	
215	E* + N2 = N + N2D + E	0.	0.00	0.	

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Appendix B

Photodissociation processes and Their Rate Coefficients

Appendix B contains information on the photodissociation, photoionization, and energetic electron impact reactions. Table B1 lists the solar fluxes in the wavelength region 116.2 to 730.0 nm along with the absorption cross sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O. Table B2 contains the absorption cross sections for N_2O_5, HNO_2, HNO_3, CH_4, CO_2, CH_2O, and HO_2.

Table B3 lists the photodissociation processes along with their total photodissociation rate coefficient. The units of all the rate coefficients presented in this table and in all the tables that follow (Tables B4-B23) are sec^{-1}. The constants in Table B3 were computed from Eq. (52) using the entire unattenuated solar flux. The values listed here are indications of the maximum rate coefficient that each process can attain.

B1. MOLECULAR OXYGEN

Two distinct processes for O_2 photodissociation are considered,

$$O_2 + h\nu \rightarrow O + O(^1D), \quad \lambda < 175\,nm$$

and

$$O_2 + h\nu \rightarrow O + O, \quad 175 < \lambda < 242.2\,nm.$$

The cross sections for this molecule are taken from the compilation of Ackerman[16] with the exception of those wavelengths in the Schumann Range bands. The photodissociation rate coefficients for the first process above are listed in Table B4, and those for the second process are listed in Table B5. The column densities given in these and all the other tables that follow (Tables B6- B23) are in units of cm^2 column.

B2. OZONE

For ozone, two processes are also considered,

$$O_3 + h\nu \rightarrow O(^1D) + O_2(^1\Delta g),\ \lambda < 310\,nm$$

and

$$O_3 + h\nu \rightarrow O + O_2,\ 310 < \lambda < 730\,nm.$$

The absorption cross sections for ozone are also taken from the compilation of Ackerman.[16] The photodissociation rate coefficients for the process with the excited products are listed in Table B6, and those for the process with the ground state products are listed in Table B7.

B3. WATER VAPOR

Water vapor is photodissociated primarily through the process

$$H_2O + h\nu \rightarrow OH + H,\ 121.4 < \lambda < 186.4\,nm.$$

The absorption cross sections for this molecule are taken from Watanabe and Zelikoff.[31] The photodissociation rate coefficients for this process are tabulated in Table B8.

[31] Watanabe, K., and Zelikoff, M.J. (1953) Absorption coefficients of water vapor in the vacuum ultraviolet, J. Opt. Soc. Am. 43:753-755.

B4. HYDROGEN PEROXIDE

According to Urey et al[B2] and Holt et al,[B3] the photodissociation process for hydrogen peroxide is probably

$$H_2O_2 + h\nu \rightarrow OH + OH, \lambda < 300\,nm.$$

The absorption cross sections above 225 nm are from Urey et al, and those below 225 nm are from Holt et al. The photodissociation rate coefficients for this molecule are presented in Table B9.

B5. NITROGEN DIOXIDE

The primary quantum yield for nitrogen dioxide is unity for the process

$$NO_2 + h\nu \rightarrow NO + O$$

for wavelengths from 398 to 244 nm. The process

$$NO_2 + h\nu \rightarrow NO + O(^1D)$$

has unity primary quantum yield from 244 to 190 nm. For these computations, however, all of the photodissociation of NO_2 is assumed to take place according to the later process. The absorption cross sections for this molecule are taken from Nakayama et al[B4] and from Hall and Blacet.[B5] The photodissociation rate coefficients for this process are listed in Table B10.

B6. THE NO_3 RADICAL

According to Johnston and Graham,[13] the photolysis of NO_3 can proceed as

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Table B4. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O(^1D)$ for the Wavelengths Below 1[illegible] nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+13	1.66806E-06	1.65171E-06	1.62513E-06	1.57431E-06	1.43824E-06	1.25387E-06	9.88396E-07	5.71980E-07	2.94155E-07	1.02772E-07
2.0E+13	1.66793E-06	1.65158E-06	1.62500E-06	1.57419E-06	1.43814E-06	1.25378E-06	9.88334E-07	5.71953E-07	2.94145E-07	1.02770E-07
5.0E+13	1.66754E-06	1.65119E-06	1.62462E-06	1.57383E-06	1.43782E-06	1.25351E-06	9.88149E-07	5.71873E-07	2.94115E-07	1.02762E-07
1.0E+14	1.66688E-06	1.65055E-06	1.62399E-06	1.57322E-06	1.43728E-06	1.25307E-06	9.87839E-07	5.71740E-07	2.94066E-07	1.02750E-07
2.0E+14	1.66558E-06	1.64926E-06	1.62273E-06	1.57201E-06	1.43621E-06	1.25219E-06	9.87221E-07	5.71474E-07	2.93967E-07	1.02725E-07
5.0E+14	1.66167E-06	1.64540E-06	1.61895E-06	1.56839E-06	1.43302E-06	1.24956E-06	9.85369E-07	5.70676E-07	2.93670E-07	1.02651E-07
1.0E+15	1.65518E-06	1.63899E-06	1.61268E-06	1.56238E-06	1.42771E-06	1.24519E-06	9.82294E-07	5.69351E-07	2.93177E-07	1.02528E-07
2.0E+15	1.64230E-06	1.62629E-06	1.60024E-06	1.55047E-06	1.41718E-06	1.23652E-06	9.76187E-07	5.66715E-07	2.92195E-07	1.02282E-07
5.0E+15	1.60450E-06	1.58897E-06	1.56372E-06	1.51546E-06	1.38623E-06	1.21102E-06	9.58212E-07	5.58929E-07	2.89282E-07	1.01550E-07
1.0E+16	1.54414E-06	1.52939E-06	1.50540E-06	1.45956E-06	1.33677E-06	1.17020E-06	9.29361E-07	5.46341E-07	2.84538E-07	1.00349E-07
2.0E+16	1.43268E-06	1.41934E-06	1.39766E-06	1.35621E-06	1.24522E-06	1.09445E-06	8.75550E-07	5.22546E-07	2.75441E-07	9.80170E-08
5.0E+16	1.16040E-06	1.15043E-06	1.13421E-06	1.10323E-06	1.02023E-06	9.07081E-07	7.40652E-07	4.60789E-07	2.50972E-07	9.15433E-08
1.0E+17	8.54413E-07	8.47991E-07	8.37554E-07	8.17620E-07	7.64191E-07	6.90938E-07	5.80801E-07	3.82530E-07	2.17829E-07	8.22435E-08
2.0E+17	5.36644E-07	5.33460E-07	5.28291E-07	5.18431E-07	4.92011E-07	4.55440E-07	3.98265E-07	2.82798E-07	1.70978E-07	6.78314E-08
5.0E+17	2.54983E-07	2.53852E-07	2.52020E-07	2.48539E-07	2.39264E-07	2.26352E-07	2.05261E-07	1.56698E-07	1.01221E-07	4.28533E-08
1.0E+18	1.36289E-07	1.35699E-07	1.34746E-07	1.32943E-07	1.28181E-07	1.21616E-07	1.10911E-07	8.58965E-08	5.64943E-08	2.44971E-08
2.0E+18	6.00193E-08	5.97393E-08	5.92891E-08	5.84436E-08	5.62472E-08	5.32901E-08	4.85643E-08	3.76423E-08	2.48191E-08	1.08074E-08
5.0E+18	1.13865E-08	1.13204E-08	1.12151E-08	1.10204E-08	1.05331E-08	9.91549E-09	8.98713E-09	6.92906E-09	4.54882E-09	1.96587E-09
1.0E+19	1.66447E-09	1.65246E-09	1.63346E-09	1.59880E-09	1.51493E-09	1.41452E-09	1.27268E-09	9.73832E-10	6.36991E-10	2.74164E-10
2.0E+19	9.58961E-11	9.48877E-11	9.32951E-11	9.04033E-11	8.35107E-11	7.55905E-11	6.54293E-11	4.79128E-11	3.10048E-11	1.33560E-11
5.0E+19	1.95990E-12	1.91295E-12	1.83731E-12	1.69528E-12	1.33423E-12	9.00690E-13	4.20783E-13	5.68626E-14	9.60759E-15	3.42372E-15
1.0E+20	4.57705E-13	4.46221E-13	4.27722E-13	3.93016E-13	3.05030E-13	2.00223E-13	8.67228E-14	7.32785E-15	1.33288E-16	7.01975E-20
2.0E+20	4.61935E-14	4.50798E-14	4.32836E-14	3.99043E-14	3.12770E-14	2.08583E-14	9.30490E-15	6.43112E-16	1.61428E-17	6.38520E-21
5.0E+20	9.31927E-17	9.10317E-17	8.75410E-17	8.09560E-17	6.40283E-17	4.33116E-17	1.98226E-17	1.90290E-18	3.84043E-20	1.57073E-23
1.0E+21	4.18059E-21	4.08390E-21	3.92769E-21	3.63297E-21	2.87498E-21	1.94652E-21	8.92285E-22	8.59497E-23	1.73975E-24	7.12828E-28
2.0E+21	8.61614E-30	8.41687E-30	8.09493E-30	7.48752E-30	5.92534E-30	4.01179E-30	1.83903E-30	1.77149E-31	3.58584E-33	1.46924E-36
5.0E+21	7.54474E-56	7.37024E-56	7.08833E-56	6.55646E-56	5.18853E-56	3.51293E-56	1.61035E-56	1.55121E-57	3.13995E-59	1.28655E-62
1.0E+22	2.80670E-99	2.74178E-99	2.63691E-99	2.43905E-99	1.93017E-99	1.30684E-99	5.99062-100	5.77062-101	1.16808-102	4.78605-106

Table B1. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O(^1D)$ for the Wavelengths Below 175 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+13	1.67913E-06	1.67912E-06	1.67911E-06	1.67908E-06	1.67902E-06	1.67885E-06	1.67858E-06	1.67802E-06	1.67635E-06	1.67358E-06
2.0E+13	1.67900E-06	1.67899E-06	1.67897E-06	1.67895E-06	1.67889E-06	1.67872E-06	1.67844E-06	1.67789E-06	1.67622E-06	1.67345E-06
5.0E+13	1.67860E-06	1.67859E-06	1.67858E-06	1.67855E-06	1.67849E-06	1.67833E-06	1.67805E-06	1.67749E-06	1.67583E-06	1.67305E-06
1.0E+14	1.67794E-06	1.67793E-06	1.67791E-06	1.67789E-06	1.67783E-06	1.67767E-06	1.67739E-06	1.67683E-06	1.67517E-06	1.67240E-06
2.0E+14	1.67662E-06	1.67662E-06	1.67660E-06	1.67657E-06	1.67652E-06	1.67635E-06	1.67607E-06	1.67552E-06	1.67385E-06	1.67109E-06
5.0E+14	1.67268E-06	1.67267E-06	1.67266E-06	1.67263E-06	1.67257E-06	1.67241E-06	1.67213E-06	1.67158E-06	1.66992E-06	1.66716E-06
1.0E+15	1.66613E-06	1.66613E-06	1.66611E-06	1.66608E-06	1.66603E-06	1.66586E-06	1.66558E-06	1.66503E-06	1.66338E-06	1.66064E-06
2.0E+15	1.65314E-06	1.65314E-06	1.65312E-06	1.65309E-06	1.65304E-06	1.65288E-06	1.65260E-06	1.65206E-06	1.65042E-06	1.64771E-06
5.0E+15	1.61501E-06	1.61501E-06	1.61499E-06	1.61496E-06	1.61491E-06	1.61475E-06	1.61449E-06	1.61396E-06	1.61237E-06	1.60974E-06
1.0E+16	1.55413E-06	1.55413E-06	1.55411E-06	1.55409E-06	1.55404E-06	1.55388E-06	1.55363E-06	1.55313E-06	1.55163E-06	1.54912E-06
2.0E+16	1.44170E-06	1.44170E-06	1.44169E-06	1.44166E-06	1.44162E-06	1.44148E-06	1.44125E-06	1.44080E-06	1.43944E-06	1.43718E-06
5.0E+16	1.16715E-06	1.16715E-06	1.16714E-06	1.16712E-06	1.16709E-06	1.16699E-06	1.16682E-06	1.16648E-06	1.16546E-06	1.16377E-06
1.0E+17	8.58763E-07	8.58761E-07	8.58754E-07	8.58743E-07	8.58721E-07	8.58656E-07	8.58546E-07	8.58327E-07	8.57672E-07	8.56582E-07
2.0E+17	5.38802E-07	5.38800E-07	5.38797E-07	5.38792E-07	5.38781E-07	5.38748E-07	5.38694E-07	5.38585E-07	5.38260E-07	5.37720E-07
5.0E+17	2.55751E-07	2.55751E-07	2.55750E-07	2.55749E-07	2.55744E-07	2.55732E-07	2.55713E-07	2.55674E-07	2.55558E-07	2.55366E-07
1.0E+18	1.36650E-07	1.36690E-07	1.36690E-07	1.36689E-07	1.36686E-07	1.36680E-07	1.36670E-07	1.36650E-07	1.36590E-07	1.36489E-07
2.0E+18	6.02101E-08	6.02101E-08	6.02098E-08	6.02093E-08	6.02083E-08	6.02055E-08	6.02006E-08	6.01910E-08	6.01622E-08	6.01143E-08
5.0E+18	1.14317E-08	1.14317E-08	1.14316E-08	1.14315E-08	1.14313E-08	1.14306E-08	1.14295E-08	1.14272E-08	1.14203E-08	1.14090E-08
1.0E+19	1.67274E-09	1.67273E-09	1.67272E-09	1.67270E-09	1.67266E-09	1.67253E-09	1.67232E-09	1.67190E-09	1.67065E-09	1.66858E-09
2.0E+19	9.65914E-11	9.65911E-11	9.65900E-11	9.65883E-11	9.65847E-11	9.65742E-11	9.65565E-11	9.65213E-11	9.64160E-11	9.62415E-11
5.0E+19	1.99185E-12	1.99183E-12	1.99178E-12	1.99170E-12	1.99154E-12	1.99106E-12	1.99025E-12	1.98864E-12	1.98382E-12	1.97581E-12
1.0E+20	4.65523E-13	4.65519E-13	4.65508E-13	4.65488E-13	4.65448E-13	4.65330E-13	4.65133E-13	4.64739E-13	4.63559E-13	4.61600E-13
2.0E+20	4.69508E-14	4.69504E-14	4.69493E-14	4.69474E-14	4.69436E-14	4.69321E-14	4.69130E-14	4.68749E-14	4.67606E-14	4.65708E-14
5.0E+20	9.46611E-17	9.46603E-17	9.46581E-17	9.46544E-17	9.46470E-17	9.46248E-17	9.45878E-17	9.45139E-17	9.42924E-17	9.39244E-17
1.0E+21	4.24629E-21	4.24626E-21	4.24616E-21	4.24599E-21	4.24566E-21	4.24467E-21	4.24301E-21	4.23971E-21	4.22980E-21	4.21333E-21
2.0E+21	8.75154E-30	8.75147E-30	8.75127E-30	8.75093E-30	8.75024E-30	8.74820E-30	8.74479E-30	8.73797E-30	8.71754E-30	8.68361E-30
5.0E+21	7.66330E-56	7.66324E-56	7.66306E-56	7.66276E-56	7.66216E-56	7.66037E-56	7.65738E-56	7.65141E-56	7.63353E-56	7.60381E-56
1.0E+22	2.85080E-99	2.85078E-99	2.85072E-99	2.85060E-99	2.85038E-99	2.84972E-99	2.84860E-99	2.84638E-99	2.83973E-99	2.82868E-99

Table B3. Total Photodissociation Rate Coefficients for Unattenuated Solar Flux

O2 + HV = O + O1D	1.67927E-06 SEC-1
O2 + HV = O + O	8.36798E-08 SEC-1
O3 + HV = O1D + O2ID	9.72665E-03 SEC-1
O3 + HV = O + O2	4.17996E-04 SEC-1
H2O + HV = OH + H	7.38662E-06 SEC-1
H2O2 + HV = OH + OH	1.59387E-04 SEC-1
NO2 + HV = NO + O1D	1.51039E-02 SEC-1
NO3 + HV = NO + O2	7.04137E-02 SEC-1
N2O + HV = N2 + O1D	7.76688E-07 SEC-1
N2O5 + HV = NO2 + NO2	6.92337E-04 SEC-1
HNO2 + HV = OH + NO	5.84756E-04 SEC-1
HNO3 + HV = OH + NO2	1.16540E-04 SEC-1
CH4 + HV = CH3 + H	9.08606E-06 SEC-1
CO2 + HV = CO + O1D	8.84043E-08 SEC-1
CO2 + HV = CO + O	8.24894E-09 SEC-1
CH2O + HV = CHO + H	2.58902E-04 SEC-1
HO2 + HV = O2 + H	1.13657E-03 SEC-1

Table B2. Absorption Cross Sections for N_2O_5, HNO_2, HNO_3, CH_4, CO_2, CH_2O, and HO_2 (Contd)

WAVELENGTH BAND ANGSTROMS	CROSS SECTIONS (CM2) N2O5	HNO2	HNO3	CH4	CO2	CH2O	HO2
3200.00-3250.00	6.00E-21	2.00E-20	1.00E-22	0.	0.	2.20E-20	0.
3250.00-3300.00	5.00E-21	2.00E-20	0.	0.	0.	3.40E-20	0.
3300.00-3350.00	3.40E-21	3.00E-20	0.	0.	0.	1.50E-20	0.
3350.00-3400.00	3.00E-21	2.80E-20	0.	0.	0.	1.20E-20	0.
3400.00-3450.00	2.40E-21	3.10E-20	0.	0.	0.	2.00E-20	0.
3450.00-3500.00	2.00E-21	3.00E-20	0.	0.	0.	5.00E-21	0.
3500.00-3550.00	1.50E-21	5.00E-20	0.	0.	0.	2.80E-21	0.
3550.00-3600.00	1.20E-21	5.00E-20	0.	0.	0.	1.20E-21	0.
3600.00-3650.00	9.00E-22	2.90E-20	0.	0.	0.	0.	0.
3650.00-3700.00	7.00E-22	8.00E-20	0.	0.	0.	0.	0.
3700.00-3750.00	4.00E-22	4.00E-20	0.	0.	0.	0.	0.
3750.00-3800.00	2.50E-22	2.00E-20	0.	0.	0.	0.	0.
3800.00-3850.00	0.	4.00E-20	0.	0.	0.	0.	0.
3850.00-3900.00	0.	5.00E-20	0.	0.	0.	0.	0.
3900.00-3950.00	0.	0.	0.	0.	0.	0.	0.
3950.00-4000.00	0.	0.	0.	0.	0.	0.	0.
4000.00-4050.00	0.	0.	0.	0.	0.	0.	0.
4050.00-4100.00	0.	0.	0.	0.	0.	0.	0.
4100.00-4150.00	0.	0.	0.	0.	0.	0.	0.
4150.00-4200.00	0.	0.	0.	0.	0.	0.	0.
4200.00-4250.00	0.	0.	0.	0.	0.	0.	0.
4250.00-4300.00	0.	0.	0.	0.	0.	0.	0.
4300.00-4350.00	0.	0.	0.	0.	0.	0.	0.
4350.00-4400.00	0.	0.	0.	0.	0.	0.	0.
4400.00-4450.00	0.	0.	0.	0.	0.	0.	0.
4450.00-4500.00	0.	0.	0.	0.	0.	0.	0.
4500.00-4550.00	0.	0.	0.	0.	0.	0.	0.
4550.00-4600.00	0.	0.	0.	0.	0.	0.	0.
4600.00-4650.00	0.	0.	0.	0.	0.	0.	0.
4650.00-4700.00	0.	0.	0.	0.	0.	0.	0.
4700.00-4750.00	0.	0.	0.	0.	0.	0.	0.
4750.00-4800.00	0.	0.	0.	0.	0.	0.	0.
4800.00-4850.00	0.	0.	0.	0.	0.	0.	0.
4850.00-4900.00	0.	0.	0.	0.	0.	0.	0.
4900.00-4950.00	0.	0.	0.	0.	0.	0.	0.
4950.00-5000.00	0.	0.	0.	0.	0.	0.	0.
5000.00-5050.00	0.	0.	0.	0.	0.	0.	0.
5050.00-5100.00	0.	0.	0.	0.	0.	0.	0.
5100.00-5150.00	0.	0.	0.	0.	0.	0.	0.
5150.00-5200.00	0.	0.	0.	0.	0.	0.	0.
5200.00-5250.00	0.	0.	0.	0.	0.	0.	0.
5250.00-5300.00	0.	0.	0.	0.	0.	0.	0.
5300.00-5350.00	0.	0.	0.	0.	0.	0.	0.
5350.00-5400.00	0.	0.	0.	0.	0.	0.	0.
5400.00-5450.00	0.	0.	0.	0.	0.	0.	0.
5450.00-5500.00	0.	0.	0.	0.	0.	0.	0.
5500.00-5550.00	0.	0.	0.	0.	0.	0.	0.
5550.00-5600.00	0.	0.	0.	0.	0.	0.	0.
5600.00-5650.00	0.	0.	0.	0.	0.	0.	0.
5650.00-5700.00	0.	0.	0.	0.	0.	0.	0.
5700.00-5750.00	0.	0.	0.	0.	0.	0.	0.

Table B2. Absorption Cross Sections for N_2O_5, HNO_2, HNO_3, CH_4, CO_2, CH_2O, and HO_2 (Contd)

WAVELENGTH BAND ANGSTROMS	CROSS SECTIONS (CM2) N2O5	HNO2	HNO3	CH4	CO2	CH2O	HO2
1792.60-1803.60	0.	0.	0.	0.	1.30E-21	0.	5.50E-18
1803.60-1816.40	0.	0.	0.	0.	1.00E-21	0.	5.50E-18
1816.40-1830.60	0.	0.	0.	0.	6.00E-22	0.	5.50E-18
1830.60-1846.20	0.	0.	0.	0.	4.00E-22	0.	5.50E-18
1846.20-1863.40	0.	0.	0.	0.	3.00E-22	0.	5.60E-18
1863.40-1882.20	0.	0.	0.	0.	1.50E-22	0.	5.70E-18
1882.20-1902.40	0.	0.	0.	0.	8.00E-23	0.	5.80E-18
1902.40-1924.00	0.	0.	0.	0.	3.00E-23	0.	5.80E-18
1924.00-1947.00	0.	0.	0.	0.	2.00E-23	0.	5.80E-18
1947.00-1971.80	0.	0.	0.	0.	1.00E-23	0.	5.80E-18
1971.80-1985.00	0.	0.	8.00E-18	0.	8.00E-24	0.	5.80E-18
1985.00-2000.00	0.	0.	7.00E-18	0.	5.50E-24	0.	5.90E-18
2000.00-2025.00	0.	0.	5.00E-18	0.	4.00E-24	0.	5.90E-18
2025.00-2050.00	0.	0.	3.80E-18	0.	3.20E-24	0.	5.90E-18
2050.00-2061.86	0.	0.	3.00E-18	0.	3.00E-24	0.	5.90E-18
2061.86-2083.33	0.	0.	2.40E-18	0.	3.00E-24	0.	6.00E-18
2083.33-2105.26	0.	0.	1.70E-18	0.	2.80E-24	0.	6.00E-18
2105.26-2127.66	5.00E-18	0.	6.00E-19	0.	2.40E-24	0.	6.00E-18
2127.66-2150.54	4.00E-18	0.	4.60E-19	0.	2.00E-24	0.	6.00E-18
2150.54-2173.91	3.30E-18	0.	3.40E-19	0.	0.	0.	5.80E-18
2173.91-2197.80	2.80E-18	0.	2.40E-19	0.	0.	0.	5.50E-18
2197.80-2222.22	2.20E-18	0.	1.50E-19	0.	0.	0.	5.00E-18
2222.22-2247.19	2.00E-18	0.	1.10E-19	0.	0.	0.	4.50E-18
2247.19-2272.73	1.50E-18	0.	9.00E-20	0.	0.	0.	4.00E-18
2272.73-2298.85	1.10E-18	0.	8.00E-20	0.	0.	0.	3.70E-18
2298.85-2325.58	1.00E-18	0.	5.50E-20	0.	0.	0.	3.00E-18
2325.58-2352.94	9.00E-19	0.	4.50E-20	0.	0.	0.	2.70E-18
2352.94-2380.95	8.00E-19	0.	3.80E-20	0.	0.	0.	2.30E-18
2380.95-2409.64	7.00E-19	0.	3.00E-20	0.	0.	0.	2.10E-18
2409.64-2439.02	6.00E-19	0.	2.80E-20	0.	0.	3.50E-21	1.70E-18
2439.02-2469.14	5.00E-19	0.	2.10E-20	0.	0.	3.80E-21	1.20E-18
2469.14-2500.00	4.00E-19	0.	2.00E-20	0.	0.	4.00E-21	1.00E-18
2500.00-2531.65	3.80E-19	0.	2.00E-20	0.	0.	6.00E-21	5.00E-19
2531.65-2564.10	3.20E-19	0.	2.00E-20	0.	0.	7.00E-21	3.80E-19
2564.10-2597.40	3.00E-19	0.	2.00E-20	0.	0.	8.00E-21	2.60E-19
2597.40-2631.58	2.40E-19	0.	2.00E-20	0.	0.	9.00E-21	1.10E-19
2631.58-2666.67	2.10E-19	0.	2.00E-20	0.	0.	1.00E-20	8.00E-20
2666.67-2702.70	1.80E-19	0.	2.00E-20	0.	0.	1.20E-20	5.00E-20
2702.70-2739.73	1.50E-19	0.	1.80E-20	0.	0.	1.50E-20	2.20E-20
2739.73-2777.78	1.30E-19	0.	1.60E-20	0.	0.	1.70E-20	0.
2777.78-2816.90	1.00E-19	0.	1.20E-20	0.	0.	1.90E-20	0.
2816.90-2857.14	8.00E-20	0	1.10E-20	0.	0.	2.10E-20	0.
2857.14-2898.55	6.00E-20	0.	9.00E-21	0.	0.	2.50E-20	0.
2898.55-2941.18	4.00E-20	0.	6.50E-21	0.	0.	3.00E-20	0.
2941.18-2985.07	3.30E-20	0.	5.00E-21	0.	0.	3.80E-20	0.
2985.07-3030.30	2.80E-20	7.00E-21	3.20E-21	0.	0.	3.00E-20	0.
3030.30-3076.92	2.10E-20	7.50E-21	2.30E-21	0.	0.	4.00E-20	0.
3076.92-3100.00	1.90E-20	9.00E-21	1.80E-21	0.	0.	3.50E-20	0.
3100.00-3150.00	1.10E-20	1.00E-20	7.00E-22	0.	0.	4.50E-20	0.
3150.00-3200.00	9.00E-21	1.10E-20	3.90E-22	0.	0.	3.00E-20	0.

Table B2. Absorption Cross Sections for N_2O_5, HNO_2, HNO_3, CH_4, CO_2, CH_2O, and HO_2

WAVELENGTH BAND ANGSTROMS	CROSS SECTIONS (CM2) N2O5	HNO2	HNO3	CH4	CO2	CH2O	HO2
1215.67-1215.67	0.	0.	0.	2.80E-17	7.30E-20	9.00E-18	0.
1162.79-1169.59	0.	0.	0.	2.80E-17	1.10E-19	0.	0.
1169.59-1176.47	0.	0.	0.	2.80E-17	8.80E-20	0.	0.
1176.47-1183.43	0.	0.	0.	2.80E-17	6.00E-20	0.	0.
1183.43-1190.48	0.	0.	0.	2.80E-17	4.70E-20	0.	0.
1190.48-1197.60	0.	0.	0.	2.80E-17	3.80E-20	0.	0.
1197.60-1204.82	0.	0.	0.	2.80E-17	4.00E-20	0.	0.
1204.82-1212.12	0.	0.	0.	2.80E-17	6.10E-20	0.	0.
1212.12-1219.51	0.	0.	0.	2.80E-17	7.40E-20	0.	0.
1219.51-1226.99	0.	0.	0.	2.80E-17	1.00E-19	0.	0.
1226.99-1234.57	0.	0.	0.	2.80E-17	1.20E-19	0.	0.
1234.57-1242.24	0.	0.	0.	2.80E-17	1.60E-19	0.	0.
1242.24-1250.00	0.	0.	0.	2.80E-17	1.80E-19	0.	0.
1250.00-1257.86	0.	0.	0.	2.80E-17	2.10E-19	0.	0.
1257.86-1265.82	0.	0.	0.	2.80E-17	2.80E-19	0.	0.
1265.82-1273.89	0.	0.	0.	2.80E-17	3.30E-19	0.	0.
1273.89-1282.05	0.	0.	0.	2.80E-17	4.20E-19	0.	0.
1282.05-1290.32	0.	0.	0.	2.80E-17	5.90E-19	0.	0.
1290.32-1298.70	0.	0.	0.	2.80E-17	7.00E-19	0.	0.
1298.70-1307.19	0.	0.	0.	2.47E-17	8.00E-19	0.	0.
1307.19-1315.79	0.	0.	0.	2.24E-17	8.30E-19	0.	0.
1315.79-1324.50	0.	0.	0.	2.07E-17	8.50E-19	0.	0.
1324.50-1333.33	0.	0.	0.	1.57E-17	8.70E-19	0.	0.
1333.33-1342.28	0.	0.	0.	1.33E-17	8.70E-19	0.	0.
1342.28-1351.35	0.	0.	0.	1.20E-17	8.70E-19	0.	0.
1351.35-1360.54	0.	0.	0.	1.00E-17	8.60E-19	0.	0.
1360.54-1369.86	0.	0.	0.	8.40E-18	8.10E-19	0.	0.
1369.86-1379.31	0.	0.	0.	5.90E-18	7.20E-19	0.	0.
1379.31-1388.89	0.	0.	0.	3.93E-18	6.40E-19	0.	0.
1388.89-1408.45	0.	0.	0.	2.24E-18	6.00E-19	0.	0.
1408.45-1428.57	0.	0.	0.	6.72E-19	5.70E-19	1.00E-17	0.
1428.57-1449.28	0.	0.	0.	6.72E-20	5.50E-19	7.00E-18	0.
1449.28-1470.59	0.	0.	0.	1.68E-20	5.70E-19	4.00E-18	0.
1470.59-1492.54	0.	0.	0.	1.12E-20	5.70E-19	5.50E-18	0.
1492.54-1515.15	0.	0.	0.	9.00E-21	5.00E-19	1.20E-17	0.
1515.15-1538.46	0.	0.	0.	5.60E-21	4.00E-19	1.80E-17	0.
1538.46-1562.50	0.	0.	0.	4.48E-21	3.00E-19	9.00E-18	0.
1562.50-1587.30	0.	0.	0.	2.80E-21	2.50E-19	8.00E-19	0.
1587.30-1612.90	0.	0.	0.	1.12E-21	1.60E-19	0.	0.
1612.90-1639.34	0.	0.	0.	8.00E-22	1.00E-19	0.	0.
1639.34-1666.67	0.	0.	0.	0.	7.00E-20	0.	0.
1666.67-1694.92	0.	0.	0.	0.	4.00E-20	1.50E-18	0.
1694.92-1724.14	0.	0.	0.	0.	1.50E-20	1.20E-17	0.
1724.14-1739.13	0.	0.	0.	0.	1.00E-20	6.00E-18	0.
1739.13-1750.00	0.	0.	0.	0.	8.00E-21	1.80E-18	0.
1750.00-1763.20	0.	0.	0.	0.	5.00E-21	0.	0.
1763.20-1768.60	0.	0.	0.	0.	3.50E-21	0.	0.
1768.60-1774.60	0.	0.	0.	0.	3.00E-21	0.	0.
1774.60-1782.60	0.	0.	0.	0.	2.00E-21	0.	0.
1782.60-1792.60	0.	0.	0.	0.	1.50E-21	0.	0.

Table B1. Solar Fluxes and Absorption Cross Sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O (Contd)

WAVELENGTH BAND ANGSTROMS	FLUX PH/CM2/S/A	CROSS SECTIONS (CM2) O2	O3	H2O	H2O2	NO2	NO3	N2O
5700.00-5750.00	5.38E+13	0.	4.75E-21	0.	0.	0.	6.00E-19	0.
5750.00-5800.00	5.42E+13	0.	4.55E-21	0.	0.	0.	7.00E-19	0.
5800.00-5850.00	5.42E+13	0.	4.35E-21	0.	0.	0.	7.00E-19	0.
5850.00-5900.00	5.42E+13	0.	4.42E-21	0.	0.	0.	9.00E-19	0.
5900.00-5950.00	5.44E+13	0.	4.61E-21	0.	0.	0.	1.00E-18	0.
5950.00-6000.00	5.44E+13	0.	4.89E-21	0.	0.	0.	9.00E-19	0.
6000.00-6050.00	5.42E+13	0.	4.84E-21	0.	0.	0.	8.00E-19	0.
6050.00-6100.00	5.40E+13	0.	4.54E-21	0.	0.	0.	7.00E-19	0.
6100.00-6150.00	5.40E+13	0.	4.24E-21	0.	0.	0.	5.00E-19	0.
6150.00-6200.00	5.40E+13	0.	3.90E-21	0.	0.	0.	4.00E-19	0.
6200.00-6250.00	5.38E+13	0.	3.60E-21	0.	0.	0.	2.00E-18	0.
6250.00-6300.00	5.36E+13	0.	3.43E-21	0.	0.	0.	1.80E-18	0.
6300.00-6350.00	5.34E+13	0.	3.17E-21	0.	0.	0.	6.00E-19	0.
6350.00-6400.00	5.32E+13	0.	2.74E-21	0.	0.	0.	4.00E-19	0.
6400.00-6450.00	5.30E+13	0.	2.61E-21	0.	0.	0.	2.20E-19	0.
6450.00-6500.00	7.90E+13	0.	2.40E-21	0.	0.	0.	2.00E-19	0.
6500.00-6600.00	5.22E+13	0.	2.07E-21	0.	0.	0.	3.00E-19	0.
6600.00-6700.00	5.18E+13	0.	1.72E-21	0.	0.	0.	2.00E-18	0.
6700.00-6800.00	5.14E+13	0.	1.37E-21	0.	0.	0.	2.00E-19	0.
6800.00-6900.00	5.09E+13	0.	1.11E-21	0.	0.	0.	0.	0.
6900.00-7000.00	5.04E+13	0.	9.13E-22	0.	0.	0.	0.	0.
7000.00-7100.00	4.99E+13	0.	7.93E-22	0.	0.	0.	0.	0.
7100.00-7200.00	4.94E+13	0.	6.40E-22	0.	0.	0.	0.	0.
7200.00-7300.00	4.90E+13	0.	5.14E-22	0.	0.	0.	0.	0.

Table B1. Solar Fluxes and Absorption Cross Sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O (Contd)

WAVELENGTH BAND ANGSTROMS	FLUX PH/CM2/S, A	O2	CROSS SECTIONS (CM2) O3	H2O	H2O2	NO2	NO3	N2O
3200.00-3250.00	1.62E+13	0.	1.50E-20	0.	0.	2.94E-19	0.	0.
3250.00-3300.00	1.94E+13	0.	7.78E-21	0.	0.	3.38E-19	0.	0.
3300.00-3350.00	1.79E+13	0.	3.72E-21	0.	0.	3.61E-19	0.	0.
3350.00-3400.00	1.89E+13	0.	1.71E-21	0.	0.	4.17E-19	0.	0.
3400.00-3450.00	2.02E+13	0.	7.46E-22	0.	0.	4.30E-19	0.	0.
3450.00-3500.00	2.06E+13	0.	2.66E-22	0.	0.	4.48E-19	0.	0.
3500.00-3550.00	2.06E+13	0.	1.09E-22	0.	0.	5.53E-19	0.	0.
3550.00-3600.00	2.08E+13	0.	5.49E-23	0.	0.	4.96E-19	0.	0.
3600.00-3650.00	2.36E+13	0.	0.	0.	0.	5.84E-19	0.	0.
3650.00-3700.00	2.46E+13	0.	0.	0.	0.	5.70E-19	0.	0.
3700.00-3750.00	2.48E+13	0.	0.	0.	0.	5.74E-19	0.	0.
3750.00-3800.00	2.34E+13	0.	0.	0.	0.	6.52E-19	0.	0.
3800.00-3850.00	2.22E+13	0.	0.	0.	0.	6.45E-19	0.	0.
3850.00-3900.00	2.18E+13	0.	0.	0.	0.	6.51E-19	0.	0.
3900.00-3950.00	2.38E+13	0.	0.	0.	0.	6.08E-19	0.	0.
3950.00-4000.00	3.08E+13	0.	0.	0.	0.	6.68E-19	0.	0.
4000.00-4050.00	3.80E+13	0.	0.	0.	0.	6.52E-19	0.	0.
4050.00-4100.00	3.98E+13	0.	2.91E-23	0.	0.	6.59E-19	0.	0.
4100.00-4150.00	3.98E+13	0.	3.14E-23	0.	0.	6.03E-19	0.	0.
4150.00-4200.00	4.04E+13	0.	3.99E-23	0.	0.	6.24E-19	0.	0.
4200.00-4250.00	4.02E+13	0.	6.54E-23	0.	0.	0.	0.	0.
4250.00-4300.00	3.88E+13	0.	6.83E-23	0.	0.	0.	0.	0.
4300.00-4350.00	3.96E+13	0.	8.66E-23	0.	0.	0.	0.	0.
4350.00-4400.00	4.50E+13	0.	1.25E-22	0.	0.	0.	0.	0.
4400.00-4450.00	4.78E+13	0.	1.49E-22	0.	0.	0.	0.	0.
4450.00-4500.00	4.96E+13	0.	1.71E-22	0.	0.	0.	0.	0.
4500.00-4550.00	4.98E+13	0.	2.12E-22	0.	0.	0.	6.00E-20	0.
4550.00-4600.00	4.96E+13	0.	3.57E-22	0.	0.	0.	1.00E-19	0.
4600.00-4650.00	5.00E+13	0.	3.68E-22	0.	0.	0.	8.00E-20	0.
4650.00-4700.00	5.10E+13	0.	4.06E-22	0.	0.	0.	1.20E-19	0.
4700.00-4750.00	5.22E+13	0.	4.89E-22	0.	0.	0.	1.80E-19	0.
4750.00-4800.00	5.18E+13	0.	7.11E-22	0.	0.	0.	2.40E-19	0.
4800.00-4850.00	4.92E+13	0.	8.43E-22	0.	0.	0.	2.10E-19	0.
4850.00-4900.00	4.88E+13	0.	8.28E-22	0.	0.	0.	2.40E-19	0.
4900.00-4950.00	5.06E+13	0.	9.09E-22	0.	0.	0.	2.40E-19	0.
4950.00-5000.00	4.96E+13	0.	1.22E-21	0.	0.	0.	3.00E-19	0.
5000.00-5050.00	4.98E+13	0.	1.62E-21	0.	0.	0.	3.00E-19	0.
5050.00-5100.00	5.00E+13	0.	1.58E-21	0.	0.	0.	4.00E-19	0.
5100.00-5150.00	4.86E+13	0.	1.60E-21	0.	0.	0.	4.50E-19	0.
5150.00-5200.00	4.86E+13	0.	1.78E-21	0.	0.	0.	5.00E-19	0.
5200.00-5250.00	5.04E+13	0.	2.07E-21	0.	0.	0.	5.00E-19	0.
5250.00-5300.00	5.16E+13	0.	2.55E-21	0.	0.	0.	6.00E-19	0.
5300.00-5350.00	5.28E+13	0.	2.74E-21	0.	0.	0.	6.00E-19	0.
5350.00-5400.00	5.34E+13	0.	2.88E-21	0.	0.	0.	5.00E-19	0.
5400.00-5450.00	5.40E+13	0.	3.07E-21	0.	0.	0.	4.00E-19	0.
5450.00-5500.00	5.36E+13	0.	3.17E-21	0.	0.	0.	6.00E-19	0.
5500.00-5550.00	5.32E+13	0.	3.36E-21	0.	0.	0.	6.50E-19	0.
5550.00-5600.00	5.32E+13	0.	3.88E-21	0.	0.	0.	7.00E-19	0.
5600.00-5650.00	5.34E+13	0.	4.31E-21	0.	0.	0.	6.00E-19	0.
5650.00-5700.00	5.34E+13	0.	4.67E-21	0.	0.	0.	6.00E-19	0.

Table B1. Solar Fluxes and Absorption Cross Sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O (Contd)

WAVELENGTH BAND ANGSTROMS	FLUX PH/CM2/S/A	CROSS SECTIONS (CM2) O2	O3	H2O	H2O2	NO2	NO3	N2O
1792.60-1803.60	1.01E+10	0.	7.77E-19	1.02E-18	0.	0.	0.	0.
1803.60-1816.40	1.27E+10	0.	7.60E-19	6.98E-19	0.	0.	0.	0.
1816.40-1830.60	1.42E+10	0.	7.33E-19	3.64E-19	0.	0.	0.	0.
1830.60-1846.20	1.29E+10	0.	6.99E-19	1.80E-19	0.	0.	0.	0.
1846.20-1863.40	1.31E+10	0.	6.56E-19	6.51E-20	0.	0.	0.	0.
1863.40-1882.20	1.63E+10	0.	6.06E-19	0.	0.	0.	0.	0.
1882.20-1902.40	1.92E+10	0.	5.45E-19	0.	9.79E-19	0.	0.	0.
1902.40-1924.00	2.29E+10	0.	4.86E-19	0.	8.10E-19	5.25E-19	0.	1.26E-19
1924.00-1947.00	3.61E+10	0.	4.36E-19	0.	7.03E-19	4.83E-19	0.	9.00E-20
1947.00-1971.80	4.68E+10	0.	4.01E-19	0.	6.15E-19	4.00E-19	0.	8.00E-20
1971.80-1985.00	6.21E+10	0.	3.42E-19	0.	5.64E-19	3.50E-19	0.	7.00E-20
1985.00-2000.00	6.85E+10	0.	3.28E-19	0.	5.43E-19	3.30E-19	0.	5.50E-20
2000.00-2025.00	7.33E+10	0.	3.26E-19	0.	5.16E-19	3.50E-19	0.	4.00E-20
2025.00-2050.00	8.74E+10	0.	3.28E-19	0.	4.79E-19	4.00E-19	0.	2.50E-20
2050.00-2061.86	1.10E+11	1.05E-23	3.51E-19	0.	4.66E-19	4.20E-19	0.	2.00E-20
2061.86-2083.33	1.96E+11	1.00E-23	4.11E-19	0.	4.42E-19	4.30E-19	0.	1.70E-20
2083.33-2105.26	3.33E+11	9.55E-24	4.84E-19	0.	4.22E-19	4.40E-19	0.	1.10E-20
2105.26-2127.66	4.21E+11	8.93E-24	6.26E-19	0.	3.92E-19	4.54E-19	0.	4.00E-21
2127.66-2150.54	4.63E+11	8.28E-24	8.57E-19	0.	3.63E-19	4.58E-19	0.	2.00E-21
2150.54-2173.91	5.73E+11	7.60E-24	1.17E-18	0.	3.40E-19	4.62E-19	0.	1.10E-21
2173.91-2197.80	5.53E+11	6.92E-24	1.52E-18	0.	3.19E-19	4.50E-19	0.	1.00E-21
2197.80-2222.22	7.08E+11	6.28E-24	1.97E-18	0.	2.98E-19	4.25E-19	0.	4.00E-22
2222.22-2247.19	7.21E+11	5.65E-24	2.55E-18	0.	2.67E-19	4.00E-19	0.	2.80E-22
2247.19-2272.73	7.13E+11	5.03E-24	3.24E-18	0.	2.49E-19	3.50E-19	0.	2.00E-22
2272.73-2298.85	8.65E+11	4.40E-24	4.00E-18	0.	2.36E-19	3.00E-19	0.	1.20E-22
2298.85-2325.58	8.98E+11	3.76E-24	4.83E-18	0.	2.16E-19	2.50E-19	0.	7.00E-23
2325.58-2352.94	8.22E+11	3.09E-24	5.79E-18	0.	1.99E-19	2.00E-19	0.	5.00E-23
2352.94-2380.95	7.89E+11	2.44E-24	6.86E-18	0.	1.81E-19	1.18E-19	0.	3.00E-23
2380.95-2409.64	8.09E+11	1.75E-24	7.97E-18	0.	1.66E-19	1.00E-19	0.	2.00E-23
2409.64-2439.02	8.51E+11	6.74E-25	9.00E-18	0.	1.48E-19	7.00E-20	0.	1.10E-23
2439.02-2469.14	9.07E+11	0.	1.00E-17	0.	1.30E-19	5.00E-20	0.	9.00E-24
2469.14-2500.00	9.33E+11	0.	1.07E-17	0.	1.22E-19	3.60E-20	0.	8.00E-24
2500.00-2531.65	9.54E+11	0.	1.11E-17	0.	1.08E-19	2.50E-20	0.	7.00E-24
2531.65-2564.10	1.22E+12	0.	1.12E-17	0.	9.30E-20	1.50E-20	0.	6.00E-24
2564.10-2597.40	2.14E+12	0.	1.11E-17	0.	8.43E-20	1.70E-20	0.	5.00E-24
2597.40-2631.58	1.28E+12	0.	1.03E-17	0.	7.49E-20	1.90E-20	0.	5.00E-24
2631.58-2666.67	3.19E+12	0.	9.43E-18	0.	6.39E-20	2.10E-20	0.	5.00E-24
2666.67-2702.70	3.47E+12	0.	8.23E-18	0.	5.64E-20	2.90E-20	0.	5.00E-24
2702.70-2739.73	3.13E+12	0.	6.81E-18	0.	5.00E-20	3.70E-20	0.	5.20E-24
2739.73-2777.78	3.13E+12	0.	5.31E-18	0.	4.33E-20	4.20E-20	0.	5.90E-24
2777.78-2816.90	3.53E+12	0.	3.99E-18	0.	3.62E-20	5.00E-20	0.	6.00E-24
2816.90-2857.14	4.22E+12	0.	2.84E-18	0.	3.27E-20	6.50E-20	0.	5.40E-24
2857.14-2898.55	5.94E+12	0.	1.92E-18	0.	2.91E-20	8.00E-20	0.	5.20E-24
2898.55-2941.18	9.15E+12	0.	1.14E-18	0.	2.53E-20	9.00E-20	0.	5.00E-24
2941.18-2985.07	9.09E+12	0.	6.60E-19	0.	2.15E-20	1.20E-19	0.	5.10E-24
2985.07-3030.30	8.53E+12	0.	3.69E-19	0.	1.75E-20	1.33E-19	0.	5.00E-24
3030.30-3076.92	1.09E+13	0.	1.97E-19	0.	0.	1.65E-19	0.	4.20E-24
3076.92-3125.00	2.57E+13	0.	1.05E-19	0.	0.	1.97E-19	0.	3.40E-24
3125.00-3175.00	1.21E+13	0.	5.23E-20	0.	0.	2.24E-19	0.	1.70E-24
3150.00-3200.00	1.39E+13	0.	2.91E-20	0.	0.	2.61E-19	0.	0.

Table B1. Solar Fluxes and Absorption Cross Sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O

WAVELENGTH BAND ANGSTROMS	FLUX PH/CM2/S/A	CROSS SECTIONS (CM2) O2	O3	H2O	H2O2	NO2	NO3	N2O
1215.67-1215.67	3.00E+11	1.00E-20	2.32E-17	0.	0.	0.	0.	0.
1162.79-1169.59	1.51E+07	2.00E-20	7.80E-18	0.	0.	0.	0.	0.
1169.59-1176.47	3.87E+07	1.25E-18	7.97E-18	0.	0.	0.	0.	0.
1176.47-1183.43	1.61E+07	2.55E-19	8.66E-18	0.	0.	0.	0.	0.
1183.43-1190.48	1.76E+07	3.00E-20	9.51E-18	0.	0.	0.	0.	0.
1190.48-1197.60	2.55E+07	3.75E-19	1.25E-17	0.	0.	0.	0.	0.
1197.60-1204.82	2.87E+07	4.45E-18	1.84E-17	0.	0.	0.	0.	0.
1204.82-1212.12	1.01E+08	8.35E-18	2.19E-17	0.	0.	0.	0.	0.
1212.12-1219.51	3.08E+08	6.00E-19	2.30E-17	0.	0.	0.	0.	0.
1219.51-1226.99	4.91E+08	2.35E-19	2.26E-17	1.99E-17	0.	0.	0.	0.
1226.99-1234.57	1.80E+08	4.50E-19	2.06E-17	6.15E-18	0.	0.	0.	0.
1234.57-1242.24	1.51E+08	3.35E-19	1.30E-17	5.16E-18	0.	0.	0.	0.
1242.24-1250.00	9.69E+07	1.75E-17	8.91E-18	1.10E-17	0.	0.	0.	0.
1250.00-1257.86	1.05E+08	8.95E-19	7.24E-18	6.39E-18	0.	0.	0.	0.
1257.86-1265.82	1.19E+08	4.30E-19	6.09E-18	7.13E-18	0.	0.	0.	0.
1265.82-1273.89	1.03E+08	1.10E-19	5.66E-18	7.84E-18	0.	0.	0.	0.
1273.89-1282.05	7.96E+07	2.05E-19	5.87E-18	7.48E-18	0.	0.	0.	0.
1282.05-1290.32	5.71E+07	4.43E-19	6.47E-18	7.82E-18	0.	0.	0.	0.
1290.32-1298.70	7.16E+07	5.55E-19	8.14E-18	7.64E-18	0.	0.	0.	0.
1298.70-1307.19	3.89E+08	4.20E-19	1.24E-17	6.71E-18	0.	0.	0.	0.
1307.19-1315.79	2.06E+08	6.85E-19	1.52E-17	6.75E-18	0.	0.	0.	0.
1315.79-1324.50	8.68E+07	1.45E-18	1.47E-17	5.67E-18	0.	0.	0.	0.
1324.50-1333.33	1.73E+08	2.25E-18	1.51E-17	4.93E-18	0.	0.	0.	0.
1333.33-1342.28	2.79E+08	2.30E-18	1.51E-17	5.00E-18	0.	0.	0.	0.
1342.28-1351.35	1.03E+08	4.55E-18	1.65E-17	3.69E-18	0.	0.	0.	0.
1351.35-1360.54	1.62E+08	7.23E-18	1.54E-17	3.36E-18	0.	0.	0.	0.
1360.54-1369.86	1.23E+08	9.50E-18	1.35E-17	2.42E-18	0.	0.	0.	0.
1369.86-1379.31	1.37E+08	1.23E-17	1.05E-17	1.80E-18	0.	0.	0.	0.
1379.31-1388.89	1.20E+08	1.32E-17	7.97E-18	1.60E-18	0.	0.	0.	0.
1388.89-1408.45	2.93E+08	1.36E-17	7.17E-18	1.19E-18	0.	0.	0.	0.
1408.45-1428.57	2.10E+08	1.40E-17	6.28E-18	7.00E-19	0.	0.	0.	0.
1428.57-1449.28	2.49E+08	1.48E-17	5.66E-18	5.03E-19	0.	0.	0.	0.
1449.28-1470.59	2.94E+08	1.41E-17	5.23E-18	4.96E-19	0.	0.	0.	0.
1470.59-1492.54	4.06E+08	1.29E-17	4.47E-18	6.87E-19	0.	0.	0.	0.
1492.54-1515.15	4.55E+08	1.15E-17	3.69E-18	9.45E-19	0.	0.	0.	0.
1515.15-1538.46	5.96E+08	9.91E-18	2.93E-18	1.38E-18	0.	0.	0.	0.
1538.46-1562.50	9.36E+08	8.24E-18	2.19E-18	1.84E-18	0.	0.	0.	0.
1562.50-1587.30	8.59E+09	6.58E-18	1.63E-18	2.44E-18	0.	0.	0.	0.
1587.30-1612.90	8.05E+08	4.97E-18	1.20E-18	3.20E-18	0.	0.	0.	0.
1612.90-1639.34	1.29E+09	3.45E-18	9.77E-19	3.91E-18	0.	0.	0.	0.
1639.34-1666.67	2.06E+09	2.06E-18	8.66E-19	4.64E-18	0.	0.	0.	0.
1666.67-1694.92	2.84E+09	1.23E-18	9.14E-19	4.57E-18	0.	0.	0.	0.
1694.92-1724.14	4.72E+09	7.22E-19	8.17E-19	4.35E-18	0.	0.	0.	0.
1724.14-1754.39	4.93E+09	4.58E-19	8.57E-19	3.57E-18	0.	0.	0.	0.
1754.39-1785.00	5.49E+09	2.74E-19	8.40E-19	2.64E-18	0.	0.	0.	0.
1785.00-1785.20	6.25E+09	0.	8.18E-19	2.64E-18	0.	0.	0.	0.
1785.20-1785.60	7.60E+09	0.	8.04E-19	2.22E-18	0.	0.	0.	0.
1785.60-1786.00	8.44E+09	0.	8.00E-19	2.04E-18	0.	0.	0.	0.
1786.00-1786.80	8.44E+09	0.	7.96E-19	1.80E-18	0.	0.	0.	0.
1786.80-1787.60	8.66E+09	0.	7.89E-19	1.42E-18	0.	0.	0.	0.

and

$$CH_2O + h\nu \rightarrow CO + H_2$$

for wavelengths from 240 to 360 nmn. The absorption cross sections for this molecule are taken from McQuigg and Calvert[B14] and Calvert et al.[B15] These authors also give the quantum efficiencies for these processes. Table B19 lists the total photodissociation rate coefficients for formaldehyde. If both of the above processes are considered to occur for this molecule, then the values presented in Table B19 must be multiplied by the relative efficiencies as given by McQuigg and Calvert[B14] and Calvert et al[B15] for each of these reactions.

B14. THE HYDROPEROXYL RADICAL

The primary photodissociation process for the hydroperoxyl radical is

$$HO_2 + h\nu \rightarrow OH + O \quad \lambda < 456\,nm.$$

The absorption cross sections used for HO_2 are a composite of the measurements of Hochanadel et al[B16] and Paukert and Johnston.[B17] The photodissociation rate coefficients for this radical are listed in Table B20.

B14. McQuigg, R.D., and Calvert, J.G. (1969) The photodecomposition of CH_2O, CD_2O, CHDO and CH_2O-CD_2O mixtures at xenon flash lamp intensities, J. Am. Chem. Soc. 91:1590-1599.

B15. Calvert, J.G., Kerr, J.A., Demerjian, K.L., and McQuigg, R.D. (1972) Photolysis of formaldehyde as a hydrogen atom source in the lower atmosphere, Science 175:751-752.

B16. Hochanadel, C.J., Ghormley, A., and Ogren, P.J. (1972) Absorption spectrum and reaction kinetics of the HO_2 radical in the gas phase, J. Chem. Phys. 56:4426-4432.

B17. Paukert, T.T., and Johnston, A.S. (1972) Spectra and kinetics of the hydroperoxyl free radical in the gas phase, J. Chem. Phys. 56:2824-2838.

for wavelengths from 116 to 164 nm. Most of the CH_4 photodissociation occurs at the Lyman α line 121.6 nm. The values listed in Table B16 are the total photodissociation rate coefficients for methane. If the above processes have equal efficiencies, then each process would have rate coefficients equal to half of the values shown in the table. The absorption cross sections for this molecule are taken from Watanabe et al.[B10]

B12. CARBON DIOXIDE

The photolysis of carbon dioxide can be proceed by two different processes:

$$CO_2 + h\nu \rightarrow CO + O(^1D) \quad 116.2 < \lambda < 166\,nm$$

and

$$CO_2 + h\nu \rightarrow CO + O \quad 166 < \lambda < 215\,nm.$$

The absorption cross sections for this molecule are taken from Inn et al,[B11] Heimerl,[B12] and Ogawa.[B13] The photodissociation rate coefficients for the process yielding excited atomic oxygen are listed in Table B17, and those for the process yielding ground state atomic oxygen are listed in Table B18.

B13. FORMALDEHYDE

Although formaldehyde can be photodissociated in several ways, the primary photolytic processes are

$$CH_2O + h\nu \rightarrow CHO + H$$

[B10] Watanabe, K., Zelikoff, M., and Inn, E.C.Y. (1953) Absorption Coefficient of Several Atmospheric Gases, Geophys. Res. Paper, 21, Tech Rpt. AFCRL-53-23.

[B11] Inn, E.C.Y., Watanabe, K., and Zelikoff, M. (1953) Absorption coefficients of gases in the vacuum ultraviolet. Part III. CO_2, J. Chem. Phys. 21:1648-1651.

[B12] Heimerl, J. (1970) CO_2 absorption coefficient 1655-1825 A, J. Geophys. Res. 75:5574-5575.

[B13] Ogawa, M. (1971) Absorption cross sections of O_2 and CO_2 continua in the Schumann and UV regions, J. Chem. Phys. 54:2550-2556.

cule are taken from Jones and Wulf[B9] and Johnston and Graham.[13] Its photodissociation rate coefficients are listed in Table B13.

B9. NITROUS ACID

The photodissociation of nitrous acid probably proceeds as

$$HNO_2 + h\nu \rightarrow OH + NO.$$

The absorption cross sections for this molecule between 300 and 390 nm are those given by Johnston and Graham.[13] Since O_2 is not an efficient absorber of radiation in this wavelength interval, the photodissociation rate coefficients for HNO_2 are listed in Table B14 only as a function of the column density of ozone.

B10. NITRIC ACID

The primary photolytic process for nitric acid is

$$HNO_3 + h\nu \rightarrow OH + NO_2$$

over the broad wavelength region from 192 to 325 nm. The values for the absorption cross sections for this gas are taken from Johnston and Graham.[13] The nitric acid photodissociation rate coefficients are listed in Table B15.

B11. METHANE

The photodissociation processes for methane are

$$CH_4 + h\nu \rightarrow CH_3 + H$$

and

$$CH_4 + h\nu \rightarrow CH_2 + H_2$$

B9. Jones, E.J., and Wulf, O.R. (1937) The absorption coefficient of nitrogen pentoxide in the ultraviolet and the visible absorption spectrum of NO_3, J. Chem. Phys. 5:873-877.

$$NO_3 + h\nu \rightarrow NO + O_2$$

for wavelengths longer than 578 nm. For wavelengths below 578 nm, it is not known whether the products are $NO_2 + O$ or $NO + O_2$. In Table B11, all the photodissociation of this radical is assumed to produce $NO + O_2$. The absorption cross sections for this molecule are taken from Johnston and Graham.[13] Since molecular oxygen is not an efficient absorber for radiations above 450 nm, the photodissociation rate coefficients for this molecule are given only as a function of the ozone column density.

B7. NITROUS OXIDE

The primary photolytic process for nitrous oxide according to Preston and Barr[B6] is

$$N_2O + h\nu \rightarrow N_2 + O(^1D), \lambda < 337\,nm.$$

Below 210 nm, oxygen atoms in the ^1S state may be produced. For the calculations presented in this report, Table B12 was computed with all of the photodissociation of N_2O producing $O(^1D)$. The absorption cross sections below 205 nm are from Zelikoff et al[B7] and above 205 nm, from Bates and Hayes.[B8]

B8. DINITROGEN PENTOXIDE

The primary processes in the photolysis of N_2O_5 are not well understood. Jones and Wulf[B9] attribute the photodissociation of this molecule to

$$N_2O_5 + h\nu \rightarrow N_2O_4 + O \rightarrow 2NO_2 + O$$

for wavelengths from 210 to 380 nm. The absorption cross sections for this mol-

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[B6] Preston, K.F., and Barr, R.F. (1971) Primary processes in the photolysis of nitrous oxide, J. Chem. Phys. 54,3347-3348.

[B7] Zelikoff, M., Watanabe, K., and Inn, E.C.Y. (1953) Absorption coefficients of gases in the vacuum ultraviolet. Part II. Nitrous oxide, J. Chem. Phys. 21,1643-1647.

[B8] Bates, D.R., and Hays, P.B. (1967) Atmospheric nitrous oxide, Planet. Space Sci. 15,189-197.

Table B4. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O(^1D)$ (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY					
	5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20
1.0E+13	6.79854E-09	9.47067E-11	2.23187E-14	4.24957E-25	7.77344E-43	3.03675E-78
2.0E+13	6.79822E-09	9.47055E-11	2.23184E-14	4.24953E-25	7.77336E-43	3.03671E-78
5.0E+13	6.79788E-09	9.47016E-11	2.23177E-14	4.24940E-25	7.77312E-43	3.03662E-78
1.0E+14	6.79731E-09	9.46952E-11	2.23164E-14	4.24919E-25	7.77273E-43	3.03646E-78
2.0E+14	6.79618E-09	9.46824E-11	2.23139E-14	4.24876E-25	7.77195E-43	3.03614E-78
5.0E+14	6.79277E-09	9.46440E-11	2.23062E-14	4.24746E-25	7.76959E-43	3.03519E-78
1.0E+15	6.78709E-09	9.45800E-11	2.22935E-14	4.24531E-25	7.76567E-43	3.03360E-78
2.0E+15	6.77575E-09	9.44522E-11	2.22680E-14	4.24101E-25	7.75783E-43	3.03042E-78
5.0E+15	6.74192E-09	9.40702E-11	2.21919E-14	4.22813E-25	7.73437E-43	3.02091E-78
1.0E+16	6.68610E-09	9.34384E-11	2.20657E-14	4.20676E-25	7.69544E-43	3.00512E-78
2.0E+16	6.57656E-09	9.21926E-11	2.18161E-14	4.16438E-25	7.61821E-43	2.97381E-78
5.0E+16	6.26383E-09	8.85918E-11	2.10884E-14	4.04011E-25	7.39145E-43	2.88193E-78
1.0E+17	5.79071E-09	8.30146E-11	1.99426E-14	3.84213E-25	7.02941E-43	2.73539E-78
2.0E+17	4.99391E-09	7.32432E-11	1.78774E-14	3.47802E-25	6.36107E-43	2.46540E-78
5.0E+17	3.39109E-09	5.19651E-11	1.31032E-14	2.59836E-25	4.73406E-43	1.81176E-78
1.0E+18	2.01269E-09	3.17454E-11	8.18451E-15	1.63393E-25	2.93529E-43	1.09807E-78
2.0E+18	8.94428E-10	1.41535E-11	3.62480E-15	6.95328E-26	1.18981E-43	4.23429E-79
5.0E+18	1.58965E-10	2.41572E-12	5.68530E-16	8.57694E-27	1.14044E-44	3.39320E-80
1.0E+19	2.18886E-11	3.24585E-13	7.18573E-17	8.26195E-28	6.12377E-46	9.18129E-82
2.0E+19	1.07208E-12	1.60175E-14	3.57869E-18	4.01515E-29	2.29144E-47	8.03806E-84
5.0E+19	2.75090E-16	4.12506E-18	9.27565E-22	1.05462E-32	6.06327E-51	2.00427E-87
1.0E+20	3.08714E-22	4.62933E-24	1.04099E-27	1.18365E-38	6.80543E-57	2.24967E-93
2.0E+20	4.49203E-31	5.83243E-36	1.31152E-39	1.49127E-50	8.57407E-69	2.83433-105
5.0E+20	1.08004E-33	1.24725E-50	2.62283E-75	2.98228E-86	1.71467-104	5.66818-141
1.0E+21	4.90335E-38	5.66250E-55	7.55159E-89	9.46683-146	5.44298-164	1.79928-200
2.0E+21	1.01066E-46	1.16713E-63	1.55650E-97	3.69182-199	5.48464-283	0.
5.0E+21	8.84982E-73	1.02200E-89	1.36295-123	3.23274-225	0.	0.
1.0E+22	3.29220-116	3.80190-133	5.07028-167	1.20260-268	0.	0.

Table B5. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O$ for Wavelengths From 175 to 242.2 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16
1.0E+17	8.36791E-08	8.36784E-08	8.36764E-08	8.36731E-08	8.36664E-08	8.36464E-08	8.36131E-08	8.35466E-08	8.33473E-08	8.30164E-08
2.0E+17	7.96609E-08	7.96602E-08	7.96583E-08	7.96551E-08	7.96488E-08	7.96298E-08	7.95980E-08	7.95346E-08	7.93448E-08	7.90296E-08
5.0E+17	6.94462E-08	6.94456E-08	6.94440E-08	6.94412E-08	6.94357E-08	6.94190E-08	6.93913E-08	6.93359E-08	6.91701E-08	6.88949E-08
1.0E+18	5.78378E-08	5.78373E-08	5.78359E-08	5.78336E-08	5.78290E-08	5.78151E-08	5.77919E-08	5.77456E-08	5.76070E-08	5.73770E-08
2.0E+18	4.48169E-08	4.48165E-08	4.48154E-08	4.48136E-08	4.48100E-08	4.47991E-08	4.47811E-08	4.47450E-08	4.46369E-08	4.44575E-08
5.0E+18	2.84480E-08	2.84478E-08	2.84471E-08	2.84459E-08	2.84435E-08	2.84365E-08	2.84248E-08	2.84014E-08	2.83314E-08	2.82154E-08
1.0E+19	1.87404E-08	1.87402E-08	1.87397E-08	1.87390E-08	1.87374E-08	1.87326E-08	1.87246E-08	1.87087E-08	1.86612E-08	1.85824E-08
2.0E+19	1.19434E-08	1.19433E-08	1.19429E-08	1.19424E-08	1.19413E-08	1.19381E-08	1.19327E-08	1.19220E-08	1.18898E-08	1.18367E-08
5.0E+19	6.78508E-09	6.78501E-09	6.78480E-09	6.78445E-09	6.78375E-09	6.78166E-09	6.77816E-09	6.77119E-09	6.75038E-09	6.71603E-09
1.0E+20	4.62169E-09	4.62163E-09	4.62147E-09	4.62120E-09	4.62065E-09	4.61901E-09	4.61628E-09	4.61083E-09	4.59459E-09	4.56784E-09
2.0E+20	3.25814E-09	3.25810E-09	3.25796E-09	3.25773E-09	3.25728E-09	3.25592E-09	3.25365E-09	3.24914E-09	3.23568E-09	3.21355E-09
5.0E+20	3.25604E-09	3.25599E-09	3.25586E-09	3.25563E-09	3.25518E-09	3.25382E-09	3.25155E-09	3.24704E-09	3.23359E-09	3.21149E-09
1.0E+21	2.19971E-09	2.19968E-09	2.19956E-09	2.19937E-09	2.19898E-09	2.19783E-09	2.19591E-09	2.19209E-09	2.18071E-09	2.16203E-09
2.0E+21	1.75574E-09	1.75574E-09	1.75563E-09	1.75546E-09	1.75510E-09	1.75403E-09	1.75225E-09	1.74870E-09	1.73815E-09	1.72086E-09
5.0E+21	1.49053E-09	1.49050E-09	1.49040E-09	1.49023E-09	1.48989E-09	1.48887E-09	1.48[illegible]E-09	1.48381E-09	1.47379E-09	1.45738E-09
1.0E+22	1.29543E-09	1.29540E-09	1.29530E-09	1.29514E-09	1.29482E-09	1.29385E-09	1.29223E-09	1.28901E-09	1.27944E-09	1.26378E-09
2.0E+22	1.16775E-09	1.16775E-09	1.16766E-09	1.16750E-09	1.16720E-09	1.16627E-09	1.16474E-09	1.16168E-09	1.15259E-09	1.13770E-09
5.0E+22	9.58654E-10	9.58627E-10	9.58546E-10	9.58410E-10	9.58139E-10	9.57328E-10	9.55977E-10	9.53286E-10	9.45287E-10	9.32304E-10
1.0E+23	7.03317E-10	7.03295E-10	7.03229E-10	7.03118E-10	7.02897E-10	7.02234E-10	7.01131E-10	6.98933E-10	6.92405E-10	6.81737E-10
2.0E+23	4.12219E-10	4.12204E-10	4.12158E-10	4.12081E-10	4.11928E-10	4.11471E-10	4.10709E-10	4.09192E-10	4.04690E-10	3.97346E-10
5.0E+23	1.18661E-10	1.18655E-10	1.18636E-10	1.18606E-10	1.18545E-10	1.18362E-10	1.18058E-10	1.17454E-10	1.15664E-10	1.12756E-10
1.0E+24	3.05886E-11	3.05866E-11	3.05801E-11	3.05702E-11	3.05498E-11	3.04886E-11	3.03869E-11	3.01848E-11	2.95873E-11	2.86213E-11
2.0E+24	8.54771E-12	8.54716E-12	8.54551E-12	8.54276E-12	8.53727E-12	8.52082E-12	8.49349E-12	8.43918E-12	8.27895E-12	8.02063E-12
5.0E+24	2.90822E-12	2.90815E-12	2.90794E-12	2.90758E-12	2.90687E-12	2.90473E-12	2.90117E-12	2.89410E-12	2.87318E-12	2.83924E-12
1.0E+25	2.34202E-12	2.34200E-12	2.34193E-12	2.34183E-12	2.34163E-12	2.34101E-12	2.33999E-12	2.33794E-12	2.33181E-12	2.32165E-12
2.0E+25	2.32211E-12	2.32209E-12	2.32204E-12	2.32194E-12	2.32176E-12	2.32120E-12	2.32026E-12	2.31839E-12	2.31278E-12	2.30346E-12

Table B-1. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O$ for Wavelengths From 175 to 242.2 nm (Cont'd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19	2.0E+19
1.0E+17	8.23593E-08	8.04246E-08	7.73159E-08	7.14945E-08	5.66739E-08	3.86203E-08	1.80502E-08	1.93497E-09	6.22227E-11	3.88685E-13
2.0E+17	7.84037E-08	7.65612E-08	7.36013E-08	6.80606E-08	5.39608E-08	3.67881E-08	1.72141E-08	1.85505E-09	6.05895E-11	3.87938E-13
5.0E+17	6.83484E-08	6.67403E-08	6.41590E-08	5.93323E-08	4.70661E-08	3.21332E-08	1.50907E-08	1.65214E-09	5.64206E-11	3.85817E-13
1.0E+18	5.69205E-08	5.55781E-08	5.34[illegible]1E-08	4.94087E-08	3.92220E-08	2.68312E-08	1.26659E-08	1.41812E-09	5.14674E-11	3.82177E-13
2.0E+18	4.41017E-08	4.30567E-08	4.13851E-08	3.82738E-08	3.04156E-08	2.08730E-08	9.93541E-09	1.15254E-09	4.57406E-11	3.78163E-13
5.0E+18	2.79855E-08	2.73124E-08	2.62414E-08	2.42635E-08	1.93198E-08	1.33475E-08	6.46744E-09	8.07455E-10	3.77590E-11	3.70179E-13
1.0E+19	1.84265E-08	1.79722E-08	1.72547E-08	1.59439E-08	1.27178E-08	8.85386E-09	4.38021E-09	5.93023E-10	3.23310E-11	3.62676E-13
2.0E+19	1.17318E-08	1.14281E-08	1.09541E-08	1.01032E-08	8.06359E-09	5.66293E-09	2.87414E-09	4.28336E-10	2.73964E-11	3.50925E
5.0E+19	6.6485dE-09	6.45547E-09	6.[illegible]043E-09	5.64812E-09	4.48576E-09	3.17666E-09	1.66625E-09	2.81839E-10	2.18888E-11	3.3017[illegible]
1.0E+20	4.51550[illegible]-09	4.36707E-09	4.[illegible]4439E-09	3.76924E-09	2.96396E-09	2.10352E-09	1.12840E-09	2.09148E-10	1.84843E-11	3.110[illegible]
2.0E+20	3.17041E-09	3.04920E-09	2.87063E-09	2.57918E-09	1.99268E-09	1.40941E-09	7.70327E-10	1.55452E-10	1.53759E-11	2.8[illegible]13
5.0E+20	3.16838[illegible]-09	3.04728E-09	2.86888E-09	2.57769E-09	1.99168E-09	1.40879E-09	7.70035E-10	1.55397E-10	1.53705E-11	2.[illegible]3E-13
1.0E+21	2.12576E-09	2.02486E-09	1.87920E-09	1.65023E-09	1.22740E-09	8.53232E-10	4.72751E-10	1.04948E-10	1.17558E-11	[illegible]877E-13
2.0E+21	1.66732E-09	1.59453E-09	1.46199E-09	1.25788E-09	9.00217E-10	6.10129E-10	3.36480E-10	7.83265E-11	9.43953E-12	2.14125E-13
5.0E+21	1.42560E-09	1.33794E-09	1.21857E-09	1.02460E-09	7.05255E-10	4.63424E-10	2.51417E-10	5.99429E-11	7.63448E-12	1.85954E-13
1.0E+22	1.23347E-09	1.15007E-09	1.03236E-09	8.55318E-10	5.64536E-10	3.56948E-10	1.88097E-10	4.50794E-11	6.02269E-12	1.57677E-13
2.0E+22	1.10893E-09	1.02987E-09	9.18651E-10	7.52459E-10	4.64043E-10	2.98625E-10	1.54032E-10	3.66700E-11	5.00513E-12	1.36236E-13
5.0E+22	9.06936E-10	8.37738E-10	7.40991E-10	5.98057E-10	3.73317E-10	2.24810E-10	1.14036E-10	2.71906E-11	3.81188E-12	1.08378E-13
1.0E+23	6.61173E-10	6.05122E-10	5.27515E-10	4.14905E-10	2.45244E-10	1.40952E-10	6.87819E-11	1.59798E-11	2.25926E-12	6.61797E-14
2.0E+23	3.83235E-10	3.45100E-10	2.93210E-10	2.20309E-10	1.18551E-10	6.35160E-11	2.96893E-11	6.85088E-12	1.00007E-12	3.07726E-14
5.0E+23	1.07213E-10	9.25449E-11	7.34312E-11	4.86877E-11	2.03970E-11	9.64924E-12	4.57852E-12	1.21106E-12	2.05296E-13	7.24282E-15
1.0E+24	2.67951E-11	2.20719E-11	1.62007E-11	9.26161E-12	2.93456E-12	1.29966E-12	5.41249E-13	6.31005E-14	4.84552E-15	1.52144E-16
2.0E+24	7.53517E-12	6.29823E-12	4.80552E-12	3.12606E-12	1.65148E-12	1.03930E-12	4.63488E-13	4.24045E-14	1.07364E-15	1.33514E-17
5.0E+24	2.77466E-12	2.60425E-12	2.38066E-12	2.07309E-12	1.55767E-12	1.03654E-12	4.63449E-13	4.24042E-14	1.07363E-15	1.33513E-17
1.0E+25	2.30156E-12	2.24295E-12	2.15012E-12	1.97922E-12	1.55133E-12	1.03647E-12	4.63449E-13	4.24042E-14	1.07363E-15	1.33513E-17
2.0E+25	2.28494E-12	2.23026E-12	2.14203E-12	1.97593E-12	1.55111E-12	1.03647E-12	4.63449E-13	4.24042E-14	1.07363E-15	1.33513E-17

Table B5. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O$ for Wavelengths From 175 to 242.2 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+19	1.0E+20	2.0E+20	5.0E+20	1.0E+21
1.0E+17	8.73391E-18	5.25966E-25	2.73918E-39	6.48784E-82	7.83393-153
2.0E+17	8.73401E-18	5.25969E-25	2.73918E-39	6.48784E-82	7.83393-153
5.0E+17	8.73431E-18	5.25972E-25	2.73915E-39	6.48771E-82	7.83377-153
1.0E+18	8.70961E-18	5.25049E-25	2.73786E-39	6.48769E-82	7.83385-153
2.0E+18	8.70936E-18	5.25076E-25	2.73786E-39	6.48763E-82	7.83385-153
5.0E+18	8.70805E-18	5.25147E-25	2.73783E-39	6.48732E-82	7.83366-153
1.0E+19	8.68652E-18	5.24339E-25	2.73649E-39	6.48685E-82	7.83351-153
2.0E+19	8.64264E-18	5.22092E-25	2.72619E-39	6.46929E-82	7.82302-153
5.0E+19	8.55010E-18	5.19131E-25	2.72091E-39	6.46673E-82	7.82211-153
1.0E+20	8.43410E-18	5.15784E-25	2.71819E-39	6.47105E-82	7.82488-153
2.0E+20	8.21772E-18	5.09124E-25	2.70931E-39	6.47191E-82	7.82630-153
5.0E+20	8.21654E-18	5.09100E-25	2.70929E-39	6.47191E-82	7.82630-153
1.0E+21	7.75047E-18	4.94050E-25	2.68714E-39	6.46964E-82	7.82824-153
2.0E+21	7.29024E-18	4.77961E-25	2.65499E-39	6.44707E-82	7.81927-153
5.0E+21	6.81167E-18	4.59358E-25	2.60309E-39	6.36972E-82	7.73855-153
1.0E+22	6.22360E-18	4.31292E-25	2.48965E-39	6.13959E-82	7.47824-153
2.0E+22	5.60679E-18	3.94657E-25	2.30204E-39	5.70753E-82	6.97128-153
5.0E+22	4.67258E-18	3.34875E-25	1.97407E-39	4.91590E-82	6.01377-153
1.0E+23	2.96441E-18	2.16146E-25	1.28895E-39	3.23148E-82	3.96684-153
2.0E+23	1.44765E-18	1.07621E-25	6.48120E-40	1.62614E-82	1.98836-153
5.0E+23	3.74534E-19	2.86729E-26	1.74848E-40	4.38425E-83	5.32466-154
1.0E+24	8.08785E-21	6.25749E-28	3.82194E-42	9.39947E-85	1.10288-155
2.0E+24	6.83445E-22	5.20470E-29	3.13298E-43	7.54866E-86	8.60985-157
5.0E+24	6.83445E-22	5.20470E-29	3.13298E-43	7.54866E-86	8.60985-157
1.0E+25	6.83445E-22	5.20470E-29	3.13298E-43	7.54866E-86	8.60985-157
2.0E+25	6.83445E-22	5.20470E-29	3.13298E-43	7.54866E-86	8.60985-157

Table B6. Total Photodissociation Rate Coefficients for the Process $O_3 + h\nu \rightarrow O(^1D) + O_2(^1\Delta g)$ for Wavelengths Below 510nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+15	9.72657E-03	9.72651E-03	9.72631E-03	9.72597E-03	9.72530E-03	9.72328E-03	9.71992E-03	9.71321E-03	9.69311E-03	9.65972E-03
2.0E+15	9.72657E-03	9.72650E-03	9.72630E-03	9.72596E-03	9.72529E-03	9.72328E-03	9.71992E-03	9.71321E-03	9.69311E-03	9.65972E-03
5.0E+15	9.72655E-03	9.72649E-03	9.72628E-03	9.72595E-03	9.72528E-03	9.72326E-03	9.71990E-03	9.71319E-03	9.69309E-03	9.65970E-03
1.0E+16	9.72653E-03	9.72646E-03	9.72626E-03	9.72592E-03	9.72525E-03	9.72323E-03	9.71988E-03	9.71316E-03	9.69306E-03	9.65968E-03
2.0E+16	9.72648E-03	9.72641E-03	9.72621E-03	9.72587E-03	9.72520E-03	9.72319E-03	9.71983E-03	9.71312E-03	9.69302E-03	9.65963E-03
5.0E+16	9.72636E-03	9.72629E-03	9.72609E-03	9.72576E-03	9.72508E-03	9.72307E-03	9.71971E-03	9.71300E-03	9.69290E-03	9.65951E-03
1.0E+17	9.72622E-03	9.72616E-03	9.72596E-03	9.72562E-03	9.72495E-03	9.72293E-03	9.71957E-03	9.71286E-03	9.69276E-03	9.65938E-03
2.0E+17	9.72606E-03	9.72600E-03	9.72579E-03	9.72546E-03	9.72479E-03	9.72277E-03	9.71941E-03	9.71270E-03	9.69260E-03	9.65922E-03
5.0E+17	9.72585E-03	9.72579E-03	9.72559E-03	9.72526E-03	9.72458E-03	9.72257E-03	9.71921E-03	9.71250E-03	9.69240E-03	9.65902E-03
1.0E+18	9.72570E-03	9.72563E-03	9.72543E-03	9.72509E-03	9.72442E-03	9.72241E-03	9.71905E-03	9.71234E-03	9.69224E-03	9.65885E-03
2.0E+18	9.72552E-03	9.72545E-03	9.72525E-03	9.72491E-03	9.72424E-03	9.72223E-03	9.71887E-03	9.71216E-03	9.69206E-03	9.65867E-03
5.0E+18	9.72528E-03	9.72522E-03	9.72502E-03	9.72468E-03	9.72401E-03	9.72199E-03	9.71863E-03	9.71192E-03	9.69182E-03	9.65844E-03
1.0E+19	9.72514E-03	9.72507E-03	9.72487E-03	9.72453E-03	9.72386E-03	9.72184E-03	9.71849E-03	9.71178E-03	9.69168E-03	9.65830E-03
2.0E+19	9.72499E-03	9.72492E-03	9.72472E-03	9.72439E-03	9.72372E-03	9.72170E-03	9.71834E-03	9.71163E-03	9.69153E-03	9.65815E-03
5.0E+19	9.72474E-03	9.72467E-03	9.72447E-03	9.72413E-03	9.72346E-03	9.72145E-03	9.71809E-03	9.71138E-03	9.69128E-03	9.65790E-03
1.0E+20	9.72443E-03	9.72436E-03	9.72416E-03	9.72383E-03	9.72316E-03	9.72114E-03	9.71778E-03	9.71107E-03	9.69097E-03	9.65759E-03
2.0E+20	9.72394E-03	9.72387E-03	9.72367E-03	9.72333E-03	9.72266E-03	9.72065E-03	9.71729E-03	9.71058E-03	9.69048E-03	9.65710E-03
5.0E+20	9.72295E-03	9.72289E-03	9.72268E-03	9.72235E-03	9.72168E-03	9.71966E-03	9.71630E-03	9.70959E-03	9.68950E-03	9.65612E-03
1.0E+21	9.72106E-03	9.72100E-03	9.72080E-03	9.72046E-03	9.71979E-03	9.71777E-03	9.71442E-03	9.70771E-03	9.68761E-03	9.65424E-03
2.0E+21	9.71753E-03	9.71752E-03	9.71732E-03	9.71698E-03	9.71631E-03	9.71430E-03	9.71094E-03	9.70423E-03	9.68414E-03	9.65078E-03
5.0E+21	9.70763E-03	9.70757E-03	9.70736E-03	9.70703E-03	9.70636E-03	9.70434E-03	9.70099E-03	9.69429E-03	9.67421E-03	9.64087E-03
1.0E+22	9.69134E-03	9.69128E-03	9.69108E-03	9.69074E-03	9.69007E-03	9.68806E-03	9.68471E-03	9.67801E-03	9.65796E-03	9.62465E-03
2.0E+22	9.66011E-03	9.66005E-03	9.65985E-03	9.65951E-03	9.65884E-03	9.65684E-03	9.65349E-03	9.64681E-03	9.62680E-03	9.59356E-03
5.0E+22	9.57430E-03	9.57423E-03	9.57404E-03	9.57370E-03	9.57304E-03	9.57104E-03	9.56772E-03	9.56108E-03	9.54119E-03	9.50815E-03
1.0E+23	9.45231E-03	9.45224E-03	9.45205E-03	9.45172E-03	9.45106E-03	9.44908E-03	9.44579E-03	9.43921E-03	9.41949E-03	9.38676E-03
2.0E+23	9.26850E-03	9.26850E-03	9.26830E-03	9.26798E-03	9.26733E-03	9.26538E-03	9.26213E-03	9.25565E-03	9.23622E-03	9.20395E-03
5.0E+23	8.97590E-03	8.97584E-03	8.97565E-03	8.97534E-03	8.97470E-03	8.97281E-03	8.96965E-03	8.96333E-03	8.94443E-03	8.91302E-03
1.0E+24	8.79803E-03	8.79795E-03	8.79776E-03	8.79745E-03	8.79683E-03	8.79497E-03	8.79188E-03	8.78569E-03	8.76715E-03	8.73637E-03
2.0E+24	8.69314E-03	8.69308E-03	8.69290E-03	8.69259E-03	8.69198E-03	8.69015E-03	8.68709E-03	8.68095E-03	8.66271E-03	8.63235E-03
5.0E+24	8.63538E-03	8.63532E-03	8.63514E-03	8.63483E-03	8.63423E-03	8.63241E-03	8.62938E-03	8.62333E-03	8.60520E-03	8.57509E-03
1.0E+25	8.62788E-03	8.62782E-03	8.62763E-03	8.62733E-03	8.62673E-03	8.62491E-03	8.62188E-03	8.61584E-03	8.59773E-03	8.56766E-03
2.0E+25	8.62761E-03	8.62755E-03	8.62737E-03	8.62707E-03	8.62646E-03	8.62464E-03	8.62162E-03	8.61557E-03	8.59747E-03	8.56739E-03

Table B6. Total Photodissociation Rate Coefficients for the Process $O_3 + h\nu \rightarrow O(^1D) + O_2(^1\Delta g)$ for Wavelengths Below 310 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+15	9.59339E-03	9.39780E-03	9.08291E-03	8.49245E-03	6.99530E-03	5.19826E-03	3.16694E-03	1.30466E-03	6.63680E-04	3.24841E-04
2.0E+15	9.59338E-03	9.39779E-03	9.08290E-03	8.49245E-03	6.99530E-03	5.19826E-03	3.16694E-03	1.30466E-03	6.63680E-04	3.24840E-04
5.0E+15	9.59337E-03	9.39776E-03	9.08289E-03	8.49244E-03	6.99528E-03	5.19825E-03	3.16693E-03	1.30466E-03	6.63679E-04	3.24840E-04
1.0E+16	9.59334E-03	9.39775E-03	9.08286E-03	8.49241E-03	6.99526E-03	5.19823E-03	3.16692E-03	1.30465E-03	6.63677E-04	3.24840E-04
2.0E+16	9.59329E-03	9.39770E-03	9.08282E-03	8.49237E-03	6.99523E-03	5.19821E-03	3.16690E-03	1.30465E-03	6.63674E-04	3.24839E-04
5.0E+16	9.59318E-03	9.39759E-03	9.08271E-03	8.49227E-03	6.99514E-03	5.19814E-03	3.16686E-03	1.30462E-03	6.63665E-04	3.24836E-04
1.0E+17	9.59304E-03	9.39746E-03	9.08258E-03	8.49214E-03	6.99504E-03	5.19805E-03	3.16680E-03	1.30460E-03	6.63653E-04	3.24832E-04
2.0E+17	9.59288E-03	9.39730E-03	9.08243E-03	8.49200E-03	6.99492E-03	5.19796E-03	3.16672E-03	1.30456E-03	6.63630E-04	3.24824E-04
5.0E+17	9.59268E-03	9.39711E-03	9.08224E-03	8.49182E-03	6.99476E-03	5.19783E-03	3.16662E-03	1.30448E-03	6.63587E-04	3.24806E-04
1.0E+18	9.59252E-03	9.39695E-03	9.08208E-03	8.49168E-03	6.99464E-03	5.19772E-03	3.16653E-03	1.30442E-03	6.63544E-04	3.24787E-04
2.0E+18	9.59234E-03	9.39677E-03	9.08191E-03	8.49152E-03	6.99450E-03	5.19760E-03	3.16643E-03	1.30434E-03	6.63494E-04	3.24765E-04
5.0E+18	9.59211E-03	9.39655E-03	9.08170E-03	8.49131E-03	6.99432E-03	5.19745E-03	3.16630E-03	1.30425E-03	6.63429E-04	3.24736E-04
1.0E+19	9.59197E-03	9.39640E-03	9.08156E-03	8.49118E-03	6.99420E-03	5.19734E-03	3.16621E-03	1.30418E-03	6.63382E-04	3.24713E-04
2.0E+19	9.59182E-03	9.39626E-03	9.08142E-03	8.49104E-03	6.99407E-03	5.19722E-03	3.16611E-03	1.30410E-03	6.63331E-04	3.24689E-04
5.0E+19	9.59157E-03	9.39601E-03	9.08117E-03	8.49080E-03	6.99384E-03	5.19702E-03	3.16593E-03	1.30397E-03	6.63247E-04	3.24647E-04
1.0E+20	9.59127E-03	9.39571E-03	9.08087E-03	8.49051E-03	6.99357E-03	5.19678E-03	3.16573E-03	1.30384E-03	6.63163E-04	3.24606E-04
2.0E+20	9.59076E-03	9.39522E-03	9.08039E-03	8.49005E-03	6.99315E-03	5.19641E-03	3.16544E-03	1.30366E-03	6.63053E-04	3.24552E-04
5.0E+20	9.58980E-03	9.39425E-03	9.07945E-03	8.48915E-03	6.99236E-03	5.19577E-03	3.16500E-03	1.30348E-03	6.62982E-04	3.24529E-04
1.0E+21	9.58793E-03	9.39241E-03	9.07763E-03	8.48740E-03	6.99081E-03	5.19447E-03	3.16405E-03	1.30299E-03	6.62727E-04	3.24414E-04
2.0E+21	9.58448E-03	9.38901E-03	9.07430E-03	8.48421E-03	6.98799E-03	5.19214E-03	3.16241E-03	1.30223E-03	6.62374E-04	3.24269E-04
5.0E+21	9.57461E-03	9.37927E-03	9.06478E-03	8.47510E-03	6.97998E-03	5.18561E-03	3.15788E-03	1.30027E-03	6.61546E-04	3.23956E-04
1.0E+22	9.55847E-03	9.36335E-03	9.04921E-03	8.46020E-03	6.96689E-03	5.17494E-03	3.15051E-03	1.29710E-03	6.60209E-04	3.23471E-04
2.0E+22	9.52753E-03	9.33282E-03	9.01937E-03	8.43168E-03	6.94189E-03	5.15466E-03	3.13662E-03	1.29129E-03	6.57873E-04	3.22661E-04
5.0E+22	9.44251E-03	9.24906E-03	8.93748E-03	8.35348E-03	6.87359E-03	5.09956E-03	3.09934E-03	1.27624E-03	6.52088E-04	3.20770E-04
1.0E+23	9.32171E-03	9.12994E-03	8.82126E-03	8.24270E-03	6.77734E-03	5.02258E-03	3.04812E-03	1.25639E-03	6.44724E-04	3.18394E-04
2.0E+23	9.13989E-03	8.95089E-03	8.64678E-03	8.07693E-03	6.63473E-03	4.91042E-03	2.97595E-03	1.23084E-03	6.36150E-04	3.15680E-04
5.0E+23	8.85065E-03	8.66673E-03	8.37083E-03	7.81962E-03	6.41556E-03	4.74424E-03	2.87670E-03	1.20232E-03	6.26553E-04	3.14046E-04
1.0E+24	8.67521E-03	8.49398E-03	8.20496E-03	7.66191E-03	6.28674E-03	4.65444E-03	2.82956E-03	1.19333E-03	6.27124E-04	3.13801E-04
2.0E+24	8.57203E-03	8.39429E-03	8.10827E-03	7.57274E-03	6.21975E-03	4.60753E-03	2.80818E-03	1.19096E-03	6.26930E-04	3.13794E-04
5.0E+24	8.51528E-03	8.33889E-03	8.05530E-03	7.52433E-03	6.18260E-03	4.58363E-03	2.79826E-03	1.19023E-03	6.26979E-04	3.13794E-04
1.0E+25	8.50791E-03	8.33132E-03	8.04853E-03	7.51806E-03	6.17782E-03	4.58058E-03	2.79702E-03	1.19015E-03	6.26978E-04	3.13794E-04
2.0E+25	8.50765E-03	8.33157E-03	8.04826E-03	7.51794E-03	6.17765E-03	4.58047E-03	2.79697E-03	1.19015E-03	6.26978E-04	3.13794E-04

Table B6. Total Photodissociation Rate Coefficients for the Process $O_3 + h\nu \rightarrow O(^1D) + O_2(^1\Delta g)$ for Wavelengths Below 510 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY							
	5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20	5.0E+20	1.0E+21
1.0E+15	1.09487E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+15	1.09487E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+15	1.09487E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+16	1.09487E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+16	1.09486E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+16	1.09486E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+17	1.09486E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+17	1.09485E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+17	1.09484E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+18	1.09482E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+18	1.09480E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+18	1.09477E-04	3.98000E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+19	1.09475E-04	3.97998E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+19	1.09472E-04	3.97988E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+19	1.09456E-04	3.97934E-05	9.65151E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+20	1.09419E-04	3.97989E-05	9.65150E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+20	1.09340E-04	3.97982E-05	9.65149E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+20	1.09107E-04	3.97980E-05	9.65149E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+21	1.09007E-04	3.97961E-05	9.65146E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+21	1.09001E-04	3.97935E-05	9.65141E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+21	1.09002E-04	3.97885E-05	9.65131E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+22	1.09007E-04	3.97792E-05	9.65111E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+22	1.09017E-04	3.97652E-05	9.65080E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+22	1.08901E-04	3.97372E-05	9.65022E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+23	1.08488E-04	3.96965E-05	9.64923E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+23	1.08117E-04	3.96586E-05	9.64832E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+23	1.07921E-04	3.96340E-05	9.64769E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+24	1.07885E-04	3.96286E-05	9.64750E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+24	1.07884E-04	3.96285E-05	9.64750E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+24	1.07884E-04	3.96285E-05	9.64750E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+25	1.07884E-04	3.96285E-05	9.64750E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+25	1.07884E-04	3.96285E-05	9.64750E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50

Table B7. Total Photodissociation Rate Coefficients for the Process $O_3 + h\nu \rightarrow O + O_2$ for Wavelengths From 310 to 730 nm

O3 COLUMN DENSITY	
1.0E+14	4.17996E-04
2.0E+14	4.17995E-04
5.0E+14	4.17994E-04
1.0E+15	4.17992E-04
2.0E+15	4.17989E-04
5.0E+15	4.17978E-04
1.0E+16	4.17960E-04
2.0E+16	4.17924E-04
5.0E+16	4.17816E-04
1.0E+17	4.17636E-04
2.0E+17	4.17276E-04
5.0E+17	4.16205E-04
1.0E+18	4.14441E-04
2.0E+18	4.10992E-04
5.0E+18	4.01237E-04
1.0E+19	3.86702E-04
2.0E+19	3.62634E-04
5.0E+19	3.13047E-04
1.0E+20	2.60086E-04
2.0E+20	1.90049E-04
5.0E+20	8.70967E-05
1.0E+21	3.45505E-05

Table 88. Total Photodissociation Rate Coefficients for the Process $H_2O + h\nu \rightarrow OH + H$ for Wavelengths From 121.9 to 186.4 nm

O2 COLUMN DENSITY \ O3 COLUMN DENSITY	1.0E+11	2.0E+11	5.0E+11	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14
1.0E+13	7.38657E-06	7.38656E-06	7.38653E-06	7.38647E-06	7.38637E-06	7.38606E-06	7.38554E-06	7.38451E-06	7.38141E-06	7.37625E-06
2.0E+13	7.38653E-06	7.38652E-06	7.38649E-06	7.38643E-06	7.38633E-06	7.38602E-06	7.38550E-06	7.38447E-06	7.38137E-06	7.37621E-06
5.0E+13	7.38640E-06	7.38639E-06	7.38636E-06	7.38631E-06	7.38621E-06	7.38590E-06	7.38538E-06	7.38435E-06	7.38125E-06	7.37609E-06
1.0E+14	7.38620E-06	7.38619E-06	7.38616E-06	7.38611E-06	7.38600E-06	7.38569E-06	7.38518E-06	7.38414E-06	7.38104E-06	7.37588E-06
2.0E+14	7.38579E-06	7.38578E-06	7.38575E-06	7.38570E-06	7.38560E-06	7.38529E-06	7.38477E-06	7.38374E-06	7.38064E-06	7.37547E-06
5.0E+14	7.38457E-06	7.38456E-06	7.38453E-06	7.38448E-06	7.38437E-06	7.38406E-06	7.38355E-06	7.38251E-06	7.37941E-06	7.37425E-06
1.0E+15	7.38254E-06	7.38253E-06	7.38250E-06	7.38245E-06	7.38234E-06	7.38203E-06	7.38152E-06	7.38048E-06	7.37738E-06	7.37222E-06
2.0E+15	7.37849E-06	7.37848E-06	7.37845E-06	7.37840E-06	7.37829E-06	7.37798E-06	7.37747E-06	7.37643E-06	7.37333E-06	7.36817E-06
5.0E+15	7.36647E-06	7.36646E-06	7.36643E-06	7.36638E-06	7.36627E-06	7.36596E-06	7.36545E-06	7.36441E-06	7.36132E-06	7.35616E-06
1.0E+16	7.34685E-06	7.34684E-06	7.34680E-06	7.34675E-06	7.34665E-06	7.34634E-06	7.34582E-06	7.34479E-06	7.34169E-06	7.33654E-06
2.0E+16	7.30904E-06	7.30903E-06	7.30900E-06	7.30895E-06	7.30885E-06	7.30854E-06	7.30802E-06	7.30699E-06	7.30390E-06	7.29875E-06
5.0E+16	7.20579E-06	7.20577E-06	7.20574E-06	7.20569E-06	7.20559E-06	7.20528E-06	7.20477E-06	7.20374E-06	7.20065E-06	7.19552E-06
1.0E+17	7.06019E-06	7.06018E-06	7.06015E-06	7.06010E-06	7.06000E-06	7.05969E-06	7.05918E-06	7.05815E-06	7.05508E-06	7.04996E-06
2.0E+17	6.82192E-06	6.82191E-06	6.82188E-06	6.82183E-06	6.82172E-06	6.82142E-06	6.82091E-06	6.81989E-06	6.81683E-06	6.81174E-06
5.0E+17	6.35730E-06	6.35729E-06	6.35726E-06	6.35721E-06	6.35711E-06	6.35681E-06	6.35631E-06	6.35530E-06	6.35227E-06	6.34723E-06
1.0E+18	5.89929E-06	5.89928E-06	5.89925E-06	5.89920E-06	5.89910E-06	5.89880E-06	5.89830E-06	5.89730E-06	5.89431E-06	5.88934E-06
2.0E+18	5.40915E-06	5.40914E-06	5.40912E-06	5.40907E-06	5.40897E-06	5.40867E-06	5.40819E-06	5.40721E-06	5.40427E-06	5.39939E-06
5.0E+18	4.82323E-06	4.82322E-06	4.82319E-06	4.82314E-06	4.82305E-06	4.82277E-06	4.82230E-06	4.82136E-06	4.81854E-06	4.81385E-06
1.0E+19	4.41601E-06	4.41600E-06	4.41598E-06	4.41593E-06	4.41584E-06	4.41558E-06	4.41513E-06	4.41424E-06	4.41158E-06	4.40715E-06
2.0E+19	3.91448E-06	3.91447E-06	3.91445E-06	3.91441E-06	3.91433E-06	3.91409E-06	3.91369E-06	3.91289E-06	3.91048E-06	3.90648E-06
5.0E+19	2.88069E-06	2.88069E-06	2.88067E-06	2.88064E-06	2.88058E-06	2.88040E-06	2.88011E-06	2.87951E-06	2.87773E-06	2.87477E-06
1.0E+20	1.78257E-06	1.78256E-06	1.78255E-06	1.78254E-06	1.78250E-06	1.78239E-06	1.78221E-06	1.78185E-06	1.78077E-06	1.77897E-06
2.0E+20	7.20230E-07	7.20228E-07	7.20224E-07	7.20218E-07	7.20204E-07	7.20165E-07	7.20098E-07	7.19965E-07	7.19566E-07	7.18902E-07
5.0E+20	1.80122E-07	1.80122E-07	1.80122E-07	1.80121E-07	1.80121E-07	1.80118E-07	1.80114E-07	1.80107E-07	1.80084E-07	1.80045E-07
1.0E+21	6.60228E-08	6.60228E-08	6.60227E-08	6.60227E-08	6.60227E-08	6.60225E-08	6.60222E-08	6.60217E-08	6.60201E-08	6.60174E-08
2.0E+21	2.82041E-08	2.82041E-08	2.82040E-08	2.82040E-08	2.82040E-08	2.82040E-08	2.82039E-08	2.82036E-08	2.82030E-08	2.82020E-08
5.0E+21	1.06830E-08	1.06830E-08	1.06830E-08	1.06830E-08	1.06830E-08	1.06830E-08	1.06830E-08	1.06829E-08	1.06827E-08	1.06823E-08
1.0E+22	2.28878E-09	2.28878E-09	2.28878E-09	2.28878E-09	2.28878E-09	2.28877E-09	2.28877E-09	2.28875E-09	2.28870E-09	2.28862E-09
2.0E+22	6.07985E-10	6.07985E-10	6.07985E-10	6.07985E-10	6.07984E-10	6.07983E-10	6.07981E-10	6.07976E-10	6.07963E-10	6.07940E-10
5.0E+22	3.05080E-10	3.05080E-10	3.05080E-10	3.05080E-10	3.05080E-10	3.05079E-10	3.05078E-10	3.05076E-10	3.05068E-10	3.05056E-10
1.0E+23	2.82473E-10	2.82473E-10	2.82473E-10	2.82473E-10	2.82472E-10	2.82472E-10	2.82471E-10	2.82468E-10	2.82462E-10	2.82450E-10

Table B8. Total Photodissociation Rate Coefficients for the Process $H_2O + h\nu \rightarrow OH + H$ for Wavelengths From 121.9 to 186.4 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17
1.0E+13	7.36594E-06	7.33516E-06	7.28433E-06	7.18434E-06	6.89750E-06	6.46021E-06	5.71905E-06	4.26319E-06	3.18727E-06	2.55012E-06
2.0E+13	7.36590E-06	7.33512E-06	7.28428E-06	7.18430E-06	6.89746E-06	6.46017E-06	5.71901E-06	4.26316E-06	3.18724E-06	2.55009E-06
5.0E+13	7.36578E-06	7.33500E-06	7.28416E-06	7.18418E-06	6.89734E-06	6.46005E-06	5.71890E-06	4.26305E-06	3.18714E-06	2.55001E-06
1.0E+14	7.36558E-06	7.33480E-06	7.28396E-06	7.18398E-06	6.89714E-06	6.45985E-06	5.71871E-06	4.26287E-06	3.18698E-06	2.54987E-06
2.0E+14	7.36517E-06	7.33439E-06	7.28355E-06	7.18357E-06	6.89673E-06	6.45946E-06	5.71832E-06	4.26251E-06	3.18665E-06	2.54960E-06
5.0E+14	7.36393E-06	7.33317E-06	7.28233E-06	7.18236E-06	6.89553E-06	6.45827E-06	5.71716E-06	4.26143E-06	3.18568E-06	2.54878E-06
1.0E+15	7.36142E-06	7.33114E-06	7.28031E-06	7.18034E-06	6.89353E-06	6.45629E-06	5.71524E-06	4.25964E-06	3.18407E-06	2.54741E-06
2.0E+15	7.35787E-06	7.32710E-06	7.27627E-06	7.17631E-06	6.88953E-06	6.45235E-06	5.71140E-06	4.25607E-06	3.18084E-06	2.54468E-06
5.0E+15	7.34586E-06	7.31510E-06	7.26429E-06	7.16436E-06	6.87768E-06	6.44066E-06	5.70001E-06	4.24547E-06	3.17126E-06	2.53656E-06
1.0E+16	7.32624E-06	7.29550E-06	7.24472E-06	7.14484E-06	6.85833E-06	6.42157E-06	5.68141E-06	4.22813E-06	3.15557E-06	2.52325E-06
2.0E+16	7.28846E-06	7.25775E-06	7.20702E-06	7.10725E-06	6.82104E-06	6.38477E-06	5.64554E-06	4.19465E-06	3.12523E-06	2.49740E-06
5.0E+16	7.18526E-06	7.15463E-06	7.10403E-06	7.00454E-06	6.71913E-06	6.28416E-06	5.54735E-06	4.10273E-06	3.04146E-06	2.42547E-06
1.0E+17	7.03974E-06	7.00922E-06	6.95880E-06	6.85967E-06	6.57532E-06	6.14205E-06	5.40844E-06	3.97202E-06	2.92136E-06	2.32094E-06
2.0E+17	6.80157E-06	6.77121E-06	6.72107E-06	6.62247E-06	6.33970E-06	5.90896E-06	5.18004E-06	3.75553E-06	2.72019E-06	2.14258E-06
5.0E+17	6.33717E-06	6.30713E-06	6.25752E-06	6.15996E-06	5.88026E-06	5.45437E-06	4.73437E-06	3.33178E-06	2.32344E-06	1.78536E-06
1.0E+18	5.87940E-06	5.84973E-06	5.80072E-06	5.70437E-06	5.42817E-06	5.00780E-06	4.29774E-06	2.91851E-06	1.93689E-06	1.43551E-06
2.0E+18	5.38963E-06	5.36050E-06	5.31239E-06	5.21782E-06	4.94676E-06	4.53438E-06	3.83845E-06	2.49069E-06	1.54144E-06	1.07926E-06
5.0E+18	4.80449E-06	4.77654E-06	4.73038E-06	4.63963E-06	4.37960E-06	3.98419E-06	3.31750E-06	2.03036E-06	1.13368E-06	7.19502E-07
1.0E+19	4.39830E-06	4.37187E-06	4.32822E-06	4.24242E-06	3.99658E-06	3.62282E-06	2.99288E-06	1.77826E-06	9.35994E-07	5.55924E-07
2.0E+19	3.89849E-06	3.87464E-06	3.83524E-06	3.75781E-06	3.53595E-06	3.19868E-06	2.63035E-06	1.53522E-06	7.77633E-07	4.40097E-07
5.0E+19	2.86886E-06	2.85119E-06	2.82202E-06	2.76469E-06	2.60042E-06	2.35070E-06	1.92994E-06	1.11935E-06	5.59076E-07	3.10607E-07
1.0E+20	1.77538E-06	1.76466E-06	1.74696E-06	1.71216E-06	1.61244E-06	1.46086E-06	1.20539E-06	7.12988E-07	3.71940E-07	2.18914E-07
2.0E+20	7.17577E-07	7.13618E-07	7.07081E-07	6.94231E-07	6.57405E-07	6.01393E-07	5.06945E-07	3.24393E-07	1.96655E-07	1.36061E-07
5.0E+20	1.79968E-07	1.79739E-07	1.79359E-07	1.78610E-07	1.76451E-07	1.73122E-07	1.67344E-07	1.55077E-07	1.43577E-07	1.30845E-07
1.0E+21	6.60121E-08	6.59962E-08	6.59696E-08	6.59165E-08	6.57585E-08	6.54974E-08	6.49837E-08	6.34979E-08	6.11503E-08	5.67694E-08
2.0E+21	2.82000E-08	2.81938E-08	2.81836E-08	2.81632E-08	2.81021E-08	2.80004E-08	2.77982E-08	2.72005E-08	2.62327E-08	2.43995E-08
5.0E+21	1.06815E-08	1.06793E-08	1.06755E-08	1.06679E-08	1.06452E-08	1.06075E-08	1.05325E-08	1.03107E-08	9.95128E-09	9.26975E-09
1.0E+22	2.28846E-09	2.28797E-09	2.28717E-09	2.28555E-09	2.28071E-09	2.27267E-09	2.25667E-09	2.20936E-09	2.13270E-09	1.98730E-09
2.0E+22	6.07896E-10	6.07761E-10	6.07537E-10	6.07089E-10	6.05748E-10	6.03520E-10	5.99088E-10	5.85988E-10	5.64791E-10	5.24684E-10
5.0E+22	3.05032E-10	3.04960E-10	3.04840E-10	3.04599E-10	3.03880E-10	3.02684E-10	3.00306E-10	2.93203E-10	2.81943E-10	2.60565E-10
1.0E+23	2.82429E-10	2.82360E-10	2.82248E-10	2.82023E-10	2.81349E-10	2.80229E-10	2.78003E-10	2.71431E-10	2.60821E-10	2.40830E-10

Table B8. Total Photodissociation Rate Coefficients for the Process $H_2O + h\nu \rightarrow OH + H$ for Wavelengths From 121.9 to 186.4nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20	5.0E+20
1.0E+13	1.92246E-06	1.25722E-06	5.46968E-07	4.69360E-08	8.30989E-10	3.13497E-13	1.24002E-22	4.70744E-37	1.40762E-65	4.19584-151
2.0E+13	1.92245E-06	1.25721E-06	5.46964E-07	4.69357E-08	8.30985E-10	3.13496E-13	1.24002E-22	4.70744E-37	1.40762E-65	4.19584-151
5.0E+13	1.92239E-06	1.25717E-06	5.46952E-07	4.69349E-08	8.30972E-10	3.13493E-13	1.24002E-22	4.70744E-37	1.40762E-65	4.19584-151
1.0E+14	1.92230E-06	1.25712E-06	5.46941E-07	4.69334E-08	8.30952E-10	3.13488E-13	1.24002E-22	4.70744E-37	1.40762E-65	4.19584-151
2.0E+14	1.92211E-06	1.25701E-06	5.46890E-07	4.69305E-08	8.30911E-10	3.13478E-13	1.24001E-22	4.70744E-37	1.40762E-65	4.19584-151
5.0E+14	1.92156E-06	1.25669E-06	5.46767E-07	4.69219E-08	8.30788E-10	3.13449E-13	1.24001E-22	4.70744E-37	1.40762E-65	4.19584-151
1.0E+15	1.92063E-06	1.25615E-06	5.46561E-07	4.69075E-08	8.30584E-10	3.13400E-13	1.24000E-22	4.70744E-37	1.40762E-65	4.19584-151
2.0E+15	1.91878E-06	1.25507E-06	5.46151E-07	4.68787E-08	8.30176E-10	3.13303E-13	1.23998E-22	4.70743E-37	1.40762E-65	4.19584-151
5.0E+15	1.91328E-06	1.25186E-06	5.44926E-07	4.67928E-08	8.28955E-10	3.13012E-13	1.23992E-22	4.70743E-37	1.40762E-65	4.19584-151
1.0E+16	1.90422E-06	1.24657E-06	5.42901E-07	4.66504E-08	8.26930E-10	3.12529E-13	1.23983E-22	4.70743E-37	1.40762E-65	4.19584-151
2.0E+16	1.88654E-06	1.23619E-06	5.38914E-07	4.63691E-08	8.22923E-10	3.11572E-13	1.23965E-22	4.70743E-37	1.40762E-65	4.19584-151
5.0E+16	1.83662E-06	1.20658E-06	5.27438E-07	4.55517E-08	8.11219E-10	3.08767E-13	1.23910E-22	4.70743E-37	1.40762E-65	4.19584-151
1.0E+17	1.76241E-06	1.16175E-06	5.09773E-07	4.42723E-08	7.92723E-10	3.04302E-13	1.23823E-22	4.70743E-37	1.40762E-65	4.19584-151
2.0E+17	1.63141E-06	1.08022E-06	4.76607E-07	4.17655E-08	7.55026E-10	2.94565E-13	1.23433E-22	4.70286E-37	1.40632E-65	4.19197-151
5.0E+17	1.36039E-06	9.06076E-07	4.03288E-07	3.59825E-08	6.65582E-10	2.70930E-13	1.22406E-22	4.68932E-37	1.40246E-65	4.18046-151
1.0E+18	1.09022E-06	7.28659E-07	3.26428E-07	2.96381E-08	5.63528E-10	2.42722E-13	1.20955E-22	4.66731E-37	1.39616E-65	4.16168-151
2.0E+18	8.14274E-07	5.46233E-07	2.46519E-07	2.28901E-08	4.52332E-10	2.10869E-13	1.18777E-22	4.62521E-37	1.38401E-65	4.12548-151
5.0E+18	5.36387E-07	3.62213E-07	1.65588E-07	1.59748E-08	3.55915E-10	1.75261E-13	1.14401E-22	4.51179E-37	1.35090E-65	4.02684-151
1.0E+19	4.10798E-07	2.78686E-07	1.28502E-07	1.27069E-08	2.77544E-10	1.54356E-13	1.09395E-22	4.35489E-37	1.30460E-65	3.88884-151
2.0E+19	3.22841E-07	2.19694E-07	1.01880E-07	1.02443E-08	2.29857E-10	1.34277E-13	1.02431E-22	4.11734E-37	1.23403E-65	3.67851-151
5.0E+19	2.27439E-07	1.55232E-07	7.24053E-08	7.41035E-09	1.71387E-10	1.06409E-13	8.99826E-23	3.67342E-37	1.10184E-65	3.28448-151
1.0E+20	1.62437E-07	1.11127E-07	5.20745E-08	5.40725E-09	1.28313E-10	8.40530E-14	7.80227E-23	3.23362E-37	9.70704E-66	2.89361-151
2.0E+20	1.04156E-07	7.14751E-08	3.37009E-08	3.56743E-09	8.75905E-11	6.15006E-14	6.38836E-23	2.69464E-37	8.09655E-66	2.41356-151
5.0E+20	1.04151E-07	7.14751E-08	3.37009E-08	3.56743E-09	8.75905E-11	6.15006E-14	6.38836E-23	2.69464E-37	8.09655E-66	2.41356-151
1.0E+21	4.54621E-08	3.14083E-08	1.50104E-08	1.65583E-09	4.35838E-11	3.47797E-14	4.29870E-23	1.85582E-37	5.58139E-66	1.66381-151
2.0E+21	1.96353E-08	1.36752E-08	6.64109E-09	7.67802E-10	2.17352E-11	1.94766E-14	2.73702E-23	1.19715E-37	3.60025E-66	1.07323-151
5.0E+21	7.49321E-09	5.25744E-09	2.59052E-09	3.12148E-10	9.39104E-12	9.21005E-15	1.42319E-23	6.27559E-38	1.88588E-66	5.62169-152
1.0E+22	1.60809E-09	1.13033E-09	5.59159E-10	6.83291E-11	2.11332E-12	2.19137E-15	3.69045E-24	1.65256E-38	4.96672E-67	1.48054-152
2.0E+22	4.20746E-10	2.91428E-10	1.40184E-10	1.59283E-11	4.52356E-13	4.37401E-16	7.55264E-25	3.48454E-39	1.05148E-67	3.13457-153
5.0E+22	2.05689E-10	1.38726E-10	6.31726E-11	6.02498E-12	1.25114E-13	6.79248E-17	6.95153E-26	3.27616E-40	9.97526E-69	2.97413-154
1.0E+23	1.89593E-10	1.27265E-10	5.73596E-11	5.26449E-12	9.92411E-14	3.69711E-17	3.79418E-27	1.41534E-42	2.33328E-71	6.90008-157

Table B-1. Total Photodissociation Rate Coefficients for the Process $H_2O_2 + h\nu \rightarrow OH + OH$ for Wavelengths From 188.2 to 303 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+17	1.59387E-04	1.59386E-04	1.59384E-04	1.59380E-04	1.59373E-04	1.59351E-04	1.59314E-04	1.59241E-04	1.59021E-04	1.58655E-04
2.0E+17	1.59386E-04	1.59386E-04	1.59384E-04	1.59380E-04	1.59373E-04	1.59350E-04	1.59314E-04	1.59240E-04	1.59020E-04	1.58655E-04
5.0E+17	1.59386E-04	1.59385E-04	1.59383E-04	1.59379E-04	1.59372E-04	1.59350E-04	1.59313E-04	1.59240E-04	1.59020E-04	1.58654E-04
1.0E+18	1.59385E-04	1.59384E-04	1.59382E-04	1.59378E-04	1.59371E-04	1.59349E-04	1.59312E-04	1.59239E-04	1.59019E-04	1.58653E-04
2.0E+18	1.59382E-04	1.59382E-04	1.59380E-04	1.59376E-04	1.59368E-04	1.59346E-04	1.59310E-04	1.59236E-04	1.59016E-04	1.58651E-04
5.0E+18	1.59376E-04	1.59375E-04	1.59373E-04	1.59369E-04	1.59362E-04	1.59340E-04	1.59303E-04	1.59230E-04	1.59010E-04	1.58644E-04
1.0E+19	1.59366E-04	1.59365E-04	1.59363E-04	1.59359E-04	1.59352E-04	1.59330E-04	1.59293E-04	1.59219E-04	1.59000E-04	1.58634E-04
2.0E+19	1.59347E-04	1.59346E-04	1.59344E-04	1.59340E-04	1.59333E-04	1.59311E-04	1.59274E-04	1.59200E-04	1.58981E-04	1.58615E-04
5.0E+19	1.59298E-04	1.59297E-04	1.59295E-04	1.59291E-04	1.59284E-04	1.59262E-04	1.59225E-04	1.59151E-04	1.58932E-04	1.58566E-04
1.0E+20	1.59230E-04	1.59229E-04	1.59227E-04	1.59223E-04	1.59216E-04	1.59194E-04	1.59157E-04	1.59084E-04	1.58864E-04	1.58498E-04
2.0E+20	1.59117E-04	1.59116E-04	1.59114E-04	1.59110E-04	1.59103E-04	1.59081E-04	1.59044E-04	1.58971E-04	1.58751E-04	1.58386E-04
5.0E+20	1.59015E-04	1.59014E-04	1.59012E-04	1.59008E-04	1.59001E-04	1.58979E-04	1.58942E-04	1.58869E-04	1.58649E-04	1.58284E-04
1.0E+21	1.58681E-04	1.58680E-04	1.58678E-04	1.58674E-04	1.58667E-04	1.58645E-04	1.58608E-04	1.58535E-04	1.58315E-04	1.57951E-04
2.0E+21	1.58161E-04	1.58160E-04	1.58158E-04	1.58154E-04	1.58147E-04	1.58125E-04	1.58088E-04	1.58015E-04	1.57796E-04	1.57431E-04
5.0E+21	1.56917E-04	1.56916E-04	1.56914E-04	1.56911E-04	1.56903E-04	1.56881E-04	1.56845E-04	1.56772E-04	1.56553E-04	1.56190E-04
1.0E+22	1.54846E-04	1.54845E-04	1.54843E-04	1.54839E-04	1.54832E-04	1.54810E-04	1.54774E-04	1.54701E-04	1.54484E-04	1.54122E-04
2.0E+22	1.51283E-04	1.51282E-04	1.51280E-04	1.51277E-04	1.51269E-04	1.51248E-04	1.51212E-04	1.51140E-04	1.50925E-04	1.50567E-04
5.0E+22	1.42514E-04	1.42513E-04	1.42511E-04	1.42508E-04	1.42501E-04	1.42480E-04	1.42445E-04	1.42375E-04	1.42166E-04	1.41818E-04
1.0E+23	1.30898E-04	1.30897E-04	1.30895E-04	1.30891E-04	1.30885E-04	1.30865E-04	1.30831E-04	1.30764E-04	1.30563E-04	1.30229E-04
2.0E+23	1.16527E-04	1.16527E-04	1.16525E-04	1.16522E-04	1.16515E-04	1.16496E-04	1.16465E-04	1.16402E-04	1.16213E-04	1.15899E-04
5.0E+23	1.00617E-04	1.00616E-04	1.00614E-04	1.00612E-04	1.00606E-04	1.00589E-04	1.00560E-04	1.00503E-04	1.00332E-04	1.00048E-04
1.0E+24	9.47553E-05	9.47547E-05	9.47531E-05	9.47504E-05	9.47450E-05	9.47288E-05	9.47019E-05	9.46480E-05	9.44867E-05	9.42188E-05
2.0E+24	9.25138E-05	9.25132E-05	9.25117E-05	9.25091E-05	9.25038E-05	9.24882E-05	9.24621E-05	9.24099E-05	9.22537E-05	9.19942E-05
5.0E+24	9.15194E-05	9.15188E-05	9.15173E-05	9.15147E-05	9.15096E-05	9.14942E-05	9.14685E-05	9.14172E-05	9.12636E-05	9.10085E-05
1.0E+25	9.13956E-05	9.13951E-05	9.13936E-05	9.13910E-05	9.13859E-05	9.13705E-05	9.13449E-05	9.12937E-05	9.11405E-05	9.08859E-05
2.0E+25	9.13912E-05	9.13907E-05	9.13892E-05	9.13866E-05	9.13815E-05	9.13661E-05	9.13405E-05	9.12894E-05	9.11361E-05	9.08815E-05
5.0E+25	9.13912E-05	9.13907E-05	9.13892E-05	9.13866E-05	9.13815E-05	9.13661E-05	9.13405E-05	9.12894E-05	9.11361E-05	9.08815E-05

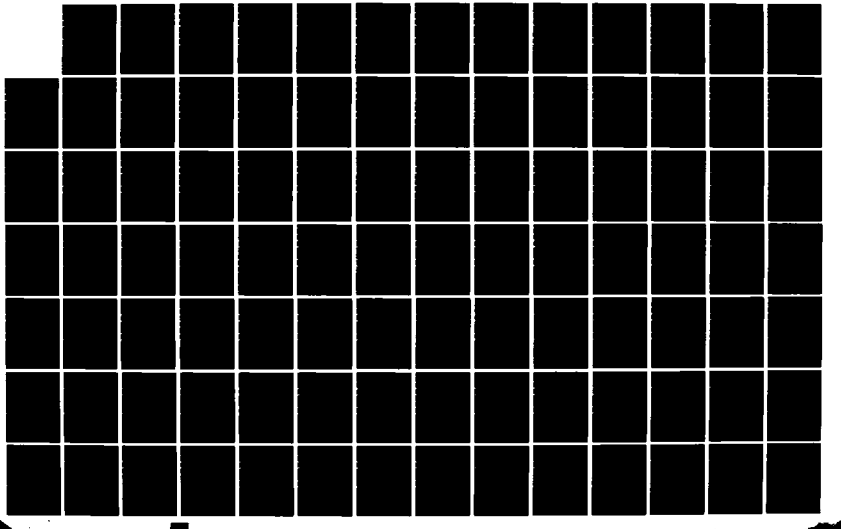
Table B-1. Total Photodissociation Rate Coefficients for the Process $H_2O_2 + h\nu \rightarrow OH + OH$ for Wavelengths From 188.2 to 308 nm (Contd)

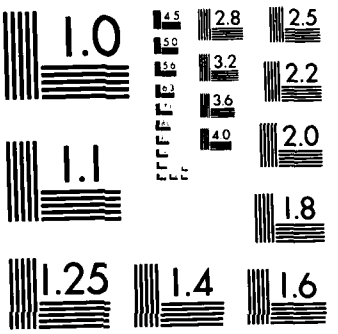
O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+17	1.57929E-04	1.55782E-04	1.52310E-04	1.45746E-04	1.28723E-04	1.07248E-04	8.02864E-05	4.71942E-05	2.81931E-05	1.39291E-05
2.0E+17	1.57928E-04	1.55781E-04	1.52310E-04	1.45746E-04	1.28723E-04	1.07248E-04	8.02862E-05	4.71940E-05	2.81930E-05	1.39290E-05
5.0E+17	1.57928E-04	1.55781E-04	1.52309E-04	1.45746E-04	1.28722E-04	1.07247E-04	8.02856E-05	4.71935E-05	2.81926E-05	1.39288E-05
1.0E+18	1.57927E-04	1.55779E-04	1.52308E-04	1.45744E-04	1.28721E-04	1.07246E-04	8.02846E-05	4.71927E-05	2.81919E-05	1.39284E-05
2.0E+18	1.57924E-04	1.55777E-04	1.52306E-04	1.45742E-04	1.28719E-04	1.07244E-04	8.02827E-05	4.71911E-05	2.81907E-05	1.39277E-05
5.0E+18	1.57918E-04	1.55771E-04	1.52299E-04	1.45736E-04	1.28713E-04	1.07238E-04	8.02770E-05	4.71863E-05	2.81871E-05	1.39255E-05
1.0E+19	1.57908E-04	1.55761E-04	1.52289E-04	1.45726E-04	1.28703E-04	1.07228E-04	8.02681E-05	4.71789E-05	2.81814E-05	1.39221E-05
2.0E+19	1.57888E-04	1.55742E-04	1.52270E-04	1.45707E-04	1.28685E-04	1.07211E-04	8.02516E-05	4.71651E-05	2.81709E-05	1.39158E-05
5.0E+19	1.57840E-04	1.55693E-04	1.52222E-04	1.45659E-04	1.28638E-04	1.07166E-04	8.02095E-05	4.71302E-05	2.81443E-05	1.38998E-05
1.0E+20	1.57772E-04	1.55625E-04	1.52154E-04	1.45592E-04	1.28573E-04	1.07103E-04	8.01518E-05	4.70826E-05	2.81082E-05	1.38779E-05
2.0E+20	1.57659E-04	1.55513E-04	1.52043E-04	1.45482E-04	1.28465E-04	1.07001E-04	8.00571E-05	4.70053E-05	2.80498E-05	1.38426E-05
5.0E+20	1.57558E-04	1.55412E-04	1.51943E-04	1.45384E-04	1.28374E-04	1.06918E-04	7.99879E-05	4.69599E-05	2.80225E-05	1.38297E-05
1.0E+21	1.57225E-04	1.55081E-04	1.51614E-04	1.45059E-04	1.28061E-04	1.06623E-04	7.97232E-05	4.67539E-05	2.78732E-05	1.37421E-05
2.0E+21	1.56705E-04	1.54565E-04	1.51102E-04	1.44555E-04	1.27560E-04	1.06175E-04	7.93277E-05	4.64582E-05	2.76662E-05	1.36243E-05
5.0E+21	1.55467E-04	1.53333E-04	1.49882E-04	1.43358E-04	1.26445E-04	1.05132E-04	7.84280E-05	4.58194E-05	2.72420E-05	1.33956E-05
1.0E+22	1.53404E-04	1.51281E-04	1.47849E-04	1.41362E-04	1.24553E-04	1.03389E-04	7.69211E-05	4.47408E-05	2.65175E-05	1.29974E-05
2.0E+22	1.49856E-04	1.47755E-04	1.44359E-04	1.37942E-04	1.21327E-04	1.00443E-04	7.44119E-05	4.30064E-05	2.53946E-05	1.24042E-05
5.0E+22	1.41127E-04	1.39085E-04	1.35785E-04	1.29557E-04	1.13463E-04	9.33263E-05	6.84478E-05	3.90351E-05	2.29249E-05	1.11594E-05
1.0E+23	1.29566E-04	1.27606E-04	1.24442E-04	1.18474E-04	1.03104E-04	8.39956E-05	6.06861E-05	3.39183E-05	1.97384E-05	9.52302E-06
2.0E+23	1.15275E-04	1.13435E-04	1.10466E-04	1.04876E-04	9.05393E-05	7.28821E-05	5.17291E-05	2.83883E-05	1.64855E-05	7.93577E-06
5.0E+23	9.94636E-05	9.78186E-05	9.51356E-05	9.00952E-05	7.72450E-05	6.16097E-05	4.32964E-05	2.39161E-05	1.41448E-05	6.88049E-06
1.0E+24	9.36864E-05	9.20162E-05	8.95869E-05	8.48393E-05	7.27602E-05	5.81211E-05	4.10755E-05	2.30816E-05	1.37856E-05	6.71577E-06
2.0E+24	9.14786E-05	8.99582E-05	8.75092E-05	8.29128E-05	7.12219E-05	5.70570E-05	4.05524E-05	2.29988E-05	1.37732E-05	6.71252E-06
5.0E+24	9.05015E-05	8.90064E-05	8.65982E-05	8.20783E-05	7.05801E-05	5.66424E-05	4.03767E-05	2.29854E-05	1.37729E-05	6.71251E-06
1.0E+25	9.03800E-05	8.88881E-05	8.64851E-05	8.19749E-05	7.05012E-05	5.65921E-05	4.03582E-05	2.29841E-05	1.37729E-05	6.71251E-06
2.0E+25	9.03757E-05	8.88839E-05	8.64811E-05	8.19713E-05	7.04984E-05	5.65903E-05	4.03575E-05	2.29840E-05	1.37729E-05	6.71251E-06
5.0E+25	9.03757E-05	8.88839E-05	8.64811E-05	8.19713E-05	7.04984E-05	5.65903E-05	4.03575E-05	2.29840E-05	1.37729E-05	6.71251E-06

Table B-1. Total Photodissociation Rate Coefficients for the Process $H_2O_2 + h\nu \rightarrow OH + OH$ for Wavelengths From 178.2 to 300 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY							
	5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20	5.0E+20	1.0E+21
1.0E+17	3.06840E-06	3.98405E-07	1.00025E-08	3.00632E-13	1.72372E-20	9.76796E-35	2.44366E-77	3.00780-148
2.0E+17	3.06839E-06	3.98494E-07	1.00025E-08	3.00632E-13	1.72372E-20	9.76795E-35	2.44365E-77	3.00780-148
5.0E+17	3.06834E-06	3.98489E-07	1.00024E-08	3.00630E-13	1.72371E-20	9.76790E-35	2.44364E-77	3.00779-148
1.0E+18	3.06825E-06	3.98480E-07	1.00023E-08	3.00628E-13	1.72369E-20	9.76782E-35	2.44362E-77	3.00776-148
2.0E+18	3.05808E-06	3.98464E-07	1.00021E-08	3.00623E-13	1.72366E-20	9.76765E-35	2.44358E-77	3.00771-148
5.0E+18	3.08758E-06	3.98416E-07	1.00014E-08	3.00607E-13	1.72357E-20	9.76717E-35	2.44347E-77	3.00757-148
1.0E+19	3.06679E-06	3.98339E-07	1.00003E-08	3.00582E-13	1.72341E-20	9.76635E-35	2.44327E-77	3.00733-148
2.0E+19	3.06532E-06	3.98192E-07	9.99808E-09	3.00531E-13	1.72311E-20	9.76473E-35	2.44288E-77	3.00684-148
5.0E+19	3.06150E-06	3.97797E-07	9.99183E-09	3.00381E-13	1.72219E-20	9.75986E-35	2.44171E-77	3.00540-148
1.0E+20	3.05619E-06	3.97223E-07	9.98207E-09	3.00134E-13	1.72067E-20	9.75178E-35	2.43976E-77	3.00299-148
2.0E+20	3.04744E-06	3.96238E-07	9.96411E-09	2.99651E-13	1.71767E-20	9.73577E-35	2.43589E-77	2.99822-148
5.0E+20	3.04502E-06	3.95999E-07	9.96032E-09	2.99599E-13	1.71756E-20	9.73571E-35	2.43589E-77	2.99822-148
1.0E+21	3.02346E-06	3.93483E-07	9.91092E-09	2.98192E-13	1.70881E-20	9.68854E-35	2.42444E-77	2.98414-148
2.0E+21	2.99480E-06	3.90040E-07	9.83867E-09	2.95988E-13	1.69486E-20	9.61232E-35	2.40587E-77	2.96130-148
5.0E+21	2.94191E-06	3.83712E-07	9.70263E-09	2.91766E-13	1.66824E-20	9.46598E-35	2.37008E-77	2.91741-148
1.0E+22	2.84524E-06	3.71293E-07	9.40340E-09	2.81018E-13	1.59618E-20	9.05682E-35	2.26929E-77	2.79392-148
2.0E+22	2.70660E-06	3.53507E-07	8.96473E-09	2.64835E-13	1.48690E-20	8.43140E-35	2.11448E-77	2.60398-148
5.0E+22	2.43341E-06	3.19813E-07	8.15846E-09	2.35940E-13	1.29412E-20	7.32892E-35	1.84046E-77	2.25691-148
1.0E+23	2.04965E-06	2.67769E-07	6.73786E-09	1.76935E-13	8.76265E-21	4.87091E-35	1.22464E-77	1.50709-148
2.0E+23	1.69456E-06	2.20257E-07	5.43161E-09	1.21507E-13	4.78734E-21	2.51090E-35	6.30669E-78	7.73536-149
5.0E+23	1.46600E-06	1.88854E-07	4.52037E-09	8.03634E-14	1.75909E-21	6.90188E-36	1.71700E-78	2.08641-149
1.0E+24	1.42056E-06	1.80997E-07	4.24356E-09	6.60642E-14	6.63379E-22	2.12690E-37	3.75249E-80	4.40693-151
2.0E+24	1.41973E-06	1.80846E-07	4.23803E-09	6.57690E-14	6.40503E-22	7.27530E-38	3.02906E-81	3.46487-152
5.0E+24	1.41973E-06	1.80846E-07	4.23803E-09	6.57690E-14	6.40503E-22	7.27530E-38	3.02906E-81	3.46487-152
1.0E+25	1.41973E-06	1.80846E-07	4.23803E-09	6.57690E-14	6.40503E-22	7.27530E-38	3.02906E-81	3.46487-152
2.0E+25	1.41973E-06	1.80846E-07	4.23803E-09	6.57690E-14	6.40503E-22	7.27530E-38	3.02906E-81	3.46487-152
5.0E+25	1.41973E-06	1.80846E-07	4.23803E-09	6.57690E-14	6.40503E-22	7.27530E-38	3.02906E-81	3.46487-152

AD-A157 122 A COMPUTER CODE FOR A ONE-DIMENSIONAL DYNAMIC MODEL OF 2/3
THE MESOSPHERS AND.. (U) AIR FORCE GEOPHYSICS LAB
HANSCOM AFB MA T J KENESHEA ET AL. 07 MAR 84
UNCLASSIFIED AFGL-TR-84-0183 F/G 4/1 NL





MICROCOPY RESOLUTION TEST CHART

Table B10. Total Photodissociation Rate Coefficients for the Process $NO_2 + h\nu \rightarrow NO + O(^1D)$ for Wavelengths From 190 to 420 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+14	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17
1.0E+19	1.51038E-02	1.51038E-02	1.51036E-02	1.51033E-02	1.51027E-02	1.51008E-02	1.50978E-02	1.50920E-02	1.50759E-02	1.50530E-02
2.0E+19	1.51038E-02	1.51038E-02	1.51036E-02	1.51033E-02	1.51026E-02	1.51008E-02	1.50978E-02	1.50920E-02	1.50759E-02	1.50530E-02
5.0E+19	1.51038E-02	1.51037E-02	1.51035E-02	1.51032E-02	1.51026E-02	1.51008E-02	1.50978E-02	1.50920E-02	1.50759E-02	1.50530E-02
1.0E+20	1.51037E-02	1.51037E-02	1.51035E-02	1.51032E-02	1.51026E-02	1.51007E-02	1.50977E-02	1.50919E-02	1.50759E-02	1.50529E-02
2.0E+20	1.51037E-02	1.51036E-02	1.51034E-02	1.51031E-02	1.51025E-02	1.51007E-02	1.50977E-02	1.50918E-02	1.50758E-02	1.50529E-02
5.0E+20	1.51035E-02	1.51035E-02	1.51033E-02	1.51030E-02	1.51024E-02	1.51005E-02	1.50975E-02	1.50917E-02	1.50757E-02	1.50528E-02
1.0E+21	1.51033E-02	1.51032E-02	1.51030E-02	1.51027E-02	1.51021E-02	1.51003E-02	1.50973E-02	1.50914E-02	1.50754E-02	1.50525E-02
2.0E+21	1.51028E-02	1.51027E-02	1.51025E-02	1.51022E-02	1.51016E-02	1.50998E-02	1.50968E-02	1.50910E-02	1.50750E-02	1.50521E-02
5.0E+21	1.51014E-02	1.51013E-02	1.51011E-02	1.51008E-02	1.51002E-02	1.50984E-02	1.50954E-02	1.50897E-02	1.50737E-02	1.50510E-02
1.0E+22	1.50991E-02	1.50991E-02	1.50989E-02	1.50986E-02	1.50980E-02	1.50962E-02	1.50932E-02	1.50875E-02	1.50717E-02	1.50491E-02
2.0E+22	1.50951E-02	1.50950E-02	1.50948E-02	1.50945E-02	1.50939E-02	1.50922E-02	1.50892E-02	1.50836E-02	1.50680E-02	1.50457E-02
5.0E+22	1.50847E-02	1.50847E-02	1.50845E-02	1.50842E-02	1.50836E-02	1.50819E-02	1.50791E-02	1.50737E-02	1.50587E-02	1.50373E-02
1.0E+23	1.50712E-02	1.50711E-02	1.50709E-02	1.50707E-02	1.50701E-02	1.50685E-02	1.50658E-02	1.50607E-02	1.50465E-02	1.50263E-02
2.0E+23	1.50543E-02	1.50543E-02	1.50541E-02	1.50538E-02	1.50533E-02	1.50519E-02	1.50494E-02	1.50447E-02	1.50316E-02	1.50131E-02
5.0E+23	1.50364E-02	1.50364E-02	1.50362E-02	1.50360E-02	1.50356E-02	1.50342E-02	1.50321E-02	1.50279E-02	1.50164E-02	1.49999E-02
1.0E+24	1.50309E-02	1.50309E-02	1.50308E-02	1.50306E-02	1.50301E-02	1.50289E-02	1.50268E-02	1.50229E-02	1.50120E-02	1.49964E-02
2.0E+24	1.50294E-02	1.50294E-02	1.50293E-02	1.50291E-02	1.50287E-02	1.50275E-02	1.50255E-02	1.50216E-02	1.50110E-02	1.49956E-02
5.0E+24	1.50289E-02	1.50289E-02	1.50288E-02	1.50286E-02	1.50282E-02	1.50270E-02	1.50250E-02	1.50212E-02	1.50106E-02	1.49954E-02
1.0E+25	1.50289E-02	1.50288E-02	1.50287E-02	1.50285E-02	1.50281E-02	1.50269E-02	1.50250E-02	1.50211E-02	1.50106E-02	1.49954E-02

Table B10. Total Photodissociation Rate Coefficients for the Process $NO_2 + h\nu \rightarrow NO + O(^1D)$ for Wavelengths From 190 to 420 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 2.0E+17	5.0E+17	1.0E+18	2.0E+18	5.0E+18
1.0E+19	1.50170E-02	1.49479E-02	1.48792E-02	1.47941E-02	1.46491E-02
2.0E+19	1.50170E-02	1.49479E-02	1.48791E-02	1.47941E-02	1.46491E-02
5.0E+19	1.50170E-02	1.49479E-02	1.48791E-02	1.47941E-02	1.46491E-02
1.0E+20	1.50170E-02	1.49479E-02	1.48791E-02	1.47940E-02	1.46491E-02
2.0E+20	1.50169E-02	1.49478E-02	1.48791E-02	1.47940E-02	1.46491E-02
5.0E+20	1.50168E-02	1.49478E-02	1.48790E-02	1.47940E-02	1.46491E-02
1.0E+21	1.50166E-02	1.49476E-02	1.48789E-02	1.47940E-02	1.46491E-02
2.0E+21	1.50162E-02	1.49473E-02	1.48788E-02	1.47939E-02	1.46490E-02
5.0E+21	1.50153E-02	1.49467E-02	1.48784E-02	1.47937E-02	1.46490E-02
1.0E+22	1.50137E-02	1.49456E-02	1.48777E-02	1.47933E-02	1.46489E-02
2.0E+22	1.50108E-02	1.49437E-02	1.48765E-02	1.47928E-02	1.46488E-02
5.0E+22	1.50038E-02	1.49391E-02	1.48738E-02	1.47915E-02	1.46485E-02
1.0E+23	1.49947E-02	1.49333E-02	1.48704E-02	1.47899E-02	1.46482E-02
2.0E+23	1.49840E-02	1.49268E-02	1.48668E-02	1.47883E-02	1.46479E-02
5.0E+23	1.49739E-02	1.49214E-02	1.48641E-02	1.47872E-02	1.46477E-02
1.0E+24	1.49715E-02	1.49204E-02	1.48637E-02	1.47870E-02	1.46477E-02
2.0E+24	1.49711E-02	1.49204E-02	1.48637E-02	1.47870E-02	1.46476E-02
5.0E+24	1.49710E-02	1.49204E-02	1.48637E-02	1.47870E-02	1.46476E-02
1.0E+25	1.49710E-02	1.49204E-02	1.48637E-02	1.47870E-02	1.46476E-02

Table B11. Total Photodissociation Rate Coefficients for the Process $NO_3 + h\nu \rightarrow NO + O_2$ for Wavelengths From 450 to 680 nm

O3 COLUMN DENSITY	
1.0E+14	7.04137E-02
2.0E+14	7.04137E-02
5.0E+14	7.04136E-02
1.0E+15	7.04135E-02
2.0E+15	7.04133E-02
5.0E+15	7.04126E-02
1.0E+16	7.04115E-02
2.0E+16	7.04093E-02
5.0E+16	7.04027E-02
1.0E+17	7.03918E-02
2.0E+17	7.03699E-02
5.0E+17	7.03042E-02
1.0E+18	7.01948E-02
2.0E+18	6.99767E-02
5.0E+18	6.93271E-02
1.0E+19	6.82601E-02
2.0E+19	6.61829E-02
5.0E+19	6.03813E-02
1.0E+20	5.19884E-02
2.0E+20	3.90163E-02
5.0E+20	1.81717E-02
1.0E+21	6.74160E-03

Table B12. Total Photodissociation Rate Coefficients for the Process $N_2O + h\nu \rightarrow N_2 + O(^1D)$ for Wavelengths From 190 to 315 nm

O2 COLUMN DENSITY \ O3 COLUMN DENSITY	1.0E+11	2.0E+11	5.0E+11	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14
1.0E+17	7.76688E-07	7.76688E-07	7.76687E-07	7.76687E-07	7.76687E-07	7.76685E-07	7.76683E-07	7.76678E-07	7.76665E-07	7.76642E-07
2.0E+17	7.76675E-07	7.76675E-07	7.76675E-07	7.76674E-07	7.76674E-07	7.76673E-07	7.76670E-07	7.76666E-07	7.76652E-07	7.76629E-07
5.0E+17	7.76637E-07	7.76637E-07	7.76636E-07	7.76636E-07	7.76636E-07	7.76634E-07	7.76632E-07	7.76628E-07	7.76614E-07	7.76591E-07
1.0E+18	7.76573E-07	7.76573E-07	7.76573E-07	7.76573E-07	7.76572E-07	7.76571E-07	7.76569E-07	7.76564E-07	7.76550E-07	7.76527E-07
2.0E+18	7.76447E-07	7.76447E-07	7.76446E-07	7.76446E-07	7.76446E-07	7.76444E-07	7.76442E-07	7.76438E-07	7.76424E-07	7.76401E-07
5.0E+18	7.76072E-07	7.76072E-07	7.76071E-07	7.76071E-07	7.76071E-07	7.76069E-07	7.76067E-07	7.76062E-07	7.76049E-07	7.76026E-07
1.0E+19	7.75460E-07	7.75460E-07	7.75460E-07	7.75460E-07	7.75459E-07	7.75458E-07	7.75456E-07	7.75451E-07	7.75437E-07	7.75414E-07
2.0E+19	7.74287E-07	7.74287E-07	7.74287E-07	7.74287E-07	7.74286E-07	7.74285E-07	7.74282E-07	7.74278E-07	7.74264E-07	7.74241E-07
5.0E+19	7.71086E-07	7.71086E-07	7.71086E-07	7.71085E-07	7.71085E-07	7.71084E-07	7.71081E-07	7.71077E-07	7.71063E-07	7.71040E-07
1.0E+20	7.66513E-07	7.66513E-07	7.66512E-07	7.66512E-07	7.66512E-07	7.66510E-07	7.66508E-07	7.66504E-07	7.66490E-07	7.66467E-07
2.0E+20	7.59021E-07	7.59021E-07	7.59021E-07	7.59021E-07	7.59020E-07	7.59019E-07	7.59017E-07	7.59012E-07	7.58999E-07	7.56976E-07
5.0E+20	7.58248E-07	7.58248E-07	7.58248E-07	7.58248E-07	7.58247E-07	7.58246E-07	7.58244E-07	7.58239E-07	7.58226E-07	7.58203E-07
1.0E+21	7.41207E-07	7.41207E-07	7.41207E-07	7.41207E-07	7.41206E-07	7.41205E-07	7.41203E-07	7.41198E-07	7.41185E-07	7.41163E-07
2.0E+21	7.20595E-07	7.20595E-07	7.20595E-07	7.20594E-07	7.20594E-07	7.20593E-07	7.20590E-07	7.20586E-07	7.20573E-07	7.20551E-07
5.0E+21	6.88458E-07	6.88458E-07	6.88458E-07	6.88458E-07	6.88457E-07	6.88456E-07	6.88454E-07	6.88450E-07	6.88437E-07	6.88416E-07
1.0E+22	6.30746E-07	6.30746E-07	6.30746E-07	6.30746E-07	6.30746E-07	6.30744E-07	6.30742E-07	6.30739E-07	6.30727E-07	6.30707E-07
2.0E+22	5.60380E-07	5.60380E-07	5.60380E-07	5.60380E-07	5.60380E-07	5.60379E-07	5.60377E-07	5.60373E-07	5.60363E-07	5.60345E-07
5.0E+22	4.41787E-07	4.41787E-07	4.41787E-07	4.41787E-07	4.41787E-07	4.41786E-07	4.41784E-07	4.41781E-07	4.41773E-07	4.41758E-07
1.0E+23	2.74667E-07	2.74667E-07	2.74667E-07	2.74667E-07	2.74667E-07	2.74666E-07	2.74665E-07	2.74663E-07	2.74657E-07	2.74646E-07
2.0E+23	1.31564E-07	1.31564E-07	1.31564E-07	1.31564E-07	1.31564E-07	1.31563E-07	1.31563E-07	1.31561E-07	1.31557E-07	1.31551E-07
5.0E+23	3.86021E-08	3.86021E-08	3.86021E-08	3.86020E-08	3.86020E-08	3.86018E-08	3.86014E-08	3.86008E-08	3.85988E-08	3.85955E-08
1.0E+24	1.89016E-08	1.89016E-08	1.89016E-08	1.89015E-08	1.89015E-08	1.89013E-08	1.89011E-08	1.89006E-08	1.88990E-08	1.88965E-08
2.0E+24	1.82305E-08	1.82305E-08	1.82305E-08	1.82305E-08	1.82305E-08	1.82303E-08	1.82301E-08	1.82296E-08	1.82281E-08	1.82257E-08
5.0E+24	1.81457E-08	1.81457E-08	1.81457E-08	1.81456E-08	1.81456E-08	1.81455E-08	1.81452E-08	1.81447E-08	1.81433E-08	1.81409E-08
1.0E+25	1.81365E-08	1.81365E-08	1.81365E-08	1.81364E-08	1.81364E-08	1.81362E-08	1.81360E-08	1.81355E-08	1.81341E-08	1.81317E-08
2.0E+25	1.81362E-08	1.81361E-08	1.81361E-08	1.81361E-08	1.81361E-08	1.81359E-08	1.81357E-08	1.81352E-08	1.81338E-08	1.81314E-08

Table B12. Total Photodissociation Rate Coefficients for the Process $N_2O + h\nu \rightarrow N_2 + O(^1D)$ for Wavelengths From 190 to 315 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17
1.0E+17	7.76596E-07	7.76458E-07	7.76229E-07	7.75772E-07	7.74405E-07	7.72142E-07	7.67675E-07	7.54704E-07	7.34323E-07	6.97141E-07
2.0E+17	7.76583E-07	7.76446E-07	7.76217E-07	7.75759E-07	7.74392E-07	7.72129E-07	7.67662E-07	7.54692E-07	7.34311E-07	6.97129E-07
5.0E+17	7.76545E-07	7.76407E-07	7.76178E-07	7.75721E-07	7.74354E-07	7.72091E-07	7.67624E-07	7.54654E-07	7.34274E-07	6.97094E-07
1.0E+18	7.76481E-07	7.76344E-07	7.76115E-07	7.75658E-07	7.74291E-07	7.72028E-07	7.67561E-07	7.54592E-07	7.34214E-07	6.97036E-07
2.0E+18	7.76355E-07	7.76218E-07	7.75989E-07	7.75531E-07	7.74164E-07	7.71902E-07	7.67436E-07	7.54469E-07	7.34093E-07	6.96921E-07
5.0E+18	7.75980E-07	7.75843E-07	7.75614E-07	7.75157E-07	7.73790E-07	7.71529E-07	7.67064E-07	7.54102E-07	7.33735E-07	6.96579E-07
1.0E+19	7.75369E-07	7.75231E-07	7.75003E-07	7.74546E-07	7.73180E-07	7.70920E-07	7.66459E-07	7.53505E-07	7.33151E-07	6.96021E-07
2.0E+19	7.74196E-07	7.74058E-07	7.73830E-07	7.73374E-07	7.72010E-07	7.69752E-07	7.65296E-07	7.52358E-07	7.32030E-07	6.94950E-07
5.0E+19	7.70995E-07	7.70858E-07	7.70630E-07	7.70175E-07	7.68816E-07	7.66566E-07	7.62124E-07	7.49229E-07	7.28972E-07	6.92028E-07
1.0E+20	7.66422E-07	7.66286E-07	7.66059E-07	7.65606E-07	7.64253E-07	7.62013E-07	7.57592E-07	7.44758E-07	7.24601E-07	6.87850E-07
2.0E+20	7.58931E-07	7.58796E-07	7.58571E-07	7.58121E-07	7.56778E-07	7.54555E-07	7.50168E-07	7.37433E-07	7.17439E-07	6.81002E-07
5.0E+20	7.58158E-07	7.58023E-07	7.57799E-07	7.57350E-07	7.56008E-07	7.53788E-07	7.49405E-07	7.36686E-07	7.16715E-07	6.80321E-07
1.0E+21	7.41119E-07	7.40986E-07	7.40765E-07	7.40324E-07	7.39005E-07	7.36824E-07	7.32518E-07	7.20026E-07	7.00426E-07	6.64748E-07
2.0E+21	7.20508E-07	7.20378E-07	7.20162E-07	7.19731E-07	7.18440E-07	7.16305E-07	7.12093E-07	6.99879E-07	6.80733E-07	6.45925E-07
5.0E+21	6.88375E-07	6.88249E-07	6.88041E-07	6.87625E-07	6.86381E-07	6.84323E-07	6.80263E-07	6.68501E-07	6.50088E-07	6.16682E-07
1.0E+22	6.30668E-07	6.30551E-07	6.30356E-07	6.29967E-07	6.28803E-07	6.26879E-07	6.23086E-07	6.12112E-07	5.94981E-07	5.64024E-07
2.0E+22	5.60309E-07	5.60202E-07	5.60024E-07	5.59669E-07	5.58608E-07	5.56855E-07	5.53400E 7	5.43429E-07	5.27919E-07	5.00042E-07
5.0E+22	4.41729E-07	4.41641E-07	4.41494E-07	4.41202E-07	4.40329E-07	4.38888E-07	4.36054E-07	4.27910E-07	4.15340E-07	3.92990E-07
1.0E+23	2.74625E-07	2.74563E-07	2.74459E-07	2.74251E-07	2.73632E-07	2.72611E-07	2.70613E-07	2.64931E-07	2.56323E-07	2.41429E-07
2.0E+23	1.31538E-07	1.31500E-07	1.31436E-07	1.31308E-07	1.30929E-07	1.30307E-07	1.29099E-07	1.25731E-07	1.20814E-07	1.12767E-07
5.0E+23	3.85889E-08	3.85692E-08	3.85364E-08	3.84712E-08	3.82778E-08	3.79634E-08	3.73623E-08	3.57555E-08	3.35931E-08	3.05016E-08
1.0E+24	1.88914E-08	1.88762E-08	1.88508E-08	1.88004E-08	1.86514E-08	1.84099E-08	1.79518E-08	1.67513E-08	1.52016E-08	1.31551E-08
2.0E+24	1.82208E-08	1.82063E-08	1.81822E-08	1.81341E-08	1.79921E-08	1.77620E-08	1.73255E-08	1.61820E-08	1.47065E-08	1.27561E-08
5.0E+24	1.81361E-08	1.81218E-08	1.80980E-08	1.80507E-08	1.79108E-08	1.76841E-08	1.72539E-08	1.61266E-08	1.46702E-08	1.27403E-08
1.0E+25	1.81269E-08	1.81127E-08	1.80889E-08	1.80417E-08	1.79020E-08	1.76756E-08	1.72462E-08	1.61207E-08	1.46664E-08	1.27388E-08
2.0E+25	1.81266E-08	1.81123E-08	1.80886E-08	1.80413E-08	1.79017E-08	1.76753E-08	1.72459E-08	1.61205E-08	1.46663E-08	1.27387E-08

Table B12. Total Photodissociation Rate Coefficients for the Process $N_2O + h\nu \rightarrow N_2 + O(^1D)$ for Wavelengths From 190 to 315 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY						
	5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19	2.0E+19	5.0E+19
1.0E+17	6.03763E-07	4.83551E-07	3.18465E-07	9.86375E-08	1.63090E-08	1.07089E-09	8.59453E-11
2.0E+17	6.03753E-07	4.83543E-07	3.18460E-07	9.86362E-08	1.63089E-08	1.07089E-09	8.59453E-11
5.0E+17	6.03723E-07	4.83519E-07	3.18444E-07	9.86322E-08	1.63084E-08	1.07088E-09	8.59453E-11
1.0E+18	6.03672E-07	4.83479E-07	3.18419E-07	9.86255E-08	1.63077E-08	1.07087E-09	8.59453E-11
2.0E+18	6.03572E-07	4.83399E-07	3.18368E-07	9.86123E-08	1.63062E-08	1.07085E-09	8.59453E-11
5.0E+18	6.03273E-07	4.83161E-07	3.18217E-07	9.85730E-08	1.63018E-08	1.07078E-09	8.59453E-11
1.0E+19	6.02787E-07	4.82774E-07	3.17971E-07	9.85087E-08	1.62946E-08	1.07066E-09	8.59453E-11
2.0E+19	6.01853E-07	4.82030E-07	3.17497E-07	9.83847E-08	1.62806E-08	1.07044E-09	8.59453E-11
5.0E+19	5.99303E-07	4.79995E-07	3.16199E-07	9.80421E-08	1.62413E-08	1.06979E-09	8.59453E-11
1.0E+20	5.95653E-07	4.77078E-07	3.14330E-07	9.75427E-08	1.61828E-08	1.06877E-09	8.59453E-11
2.0E+20	5.89662E-07	4.72279E-07	3.11242E-07	9.67042E-08	1.60817E-08	1.06692E-09	8.59452E-11
5.0E+20	5.89092E-07	4.71844E-07	3.10977E-07	9.66372E-08	1.60738E-08	1.06678E-09	8.59452E-11
1.0E+21	5.75467E-07	4.60915E-07	3.03913E-07	9.46837E-08	1.58296E-08	1.06198E-09	8.59451E-11
2.0E+21	5.59003E-07	4.47700E-07	2.95339E-07	9.22722E-08	1.55172E-08	1.05539E-09	8.59449E-11
5.0E+21	5.33511E-07	4.27298E-07	2.82119E-07	8.85198E-08	1.50175E-08	1.04420E-09	8.59446E-11
1.0E+22	4.87436E-07	3.90206E-07	2.57815E-07	8.13909E-08	1.40144E-08	1.01943E-09	8.59437E-11
2.0E+22	4.31625E-07	3.45375E-07	2.28419E-07	7.26317E-08	1.27358E-08	9.85761E-10	8.59425E-11
5.0E+22	3.38947E-07	2.71525E-07	1.80395E-07	5.83839E-08	1.06352E-08	9.29097E-10	8.59403E-11
1.0E+23	2.06846E-07	1.65135E-07	1.09845E-07	3.63482E-08	7.14610E-09	8.25112E-10	8.59359E-11
2.0E+23	9.55816E-08	7.61533E-08	5.11481E-08	1.79497E-08	4.17913E-09	7.33719E-10	8.59318E-11
5.0E+23	2.52507E-08	2.03050E-08	1.43418E-08	6.21662E-09	2.22475E-09	6.70637E-10	8.59289E-11
1.0E+24	1.02400E-08	8.04676E-09	5.85509E-09	3.22418E-09	1.67355E-09	6.50942E-10	8.59279E-11
2.0E+24	9.95878E-09	7.83253E-09	5.70855E-09	3.17142E-09	1.66353E-09	6.50572E-10	8.59278E-11
5.0E+24	9.95734E-09	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09	6.50572E-10	8.59278E-11
1.0E+25	9.95724E-09	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09	6.50572E-10	8.59278E-11
2.0E+25	9.95723E-09	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09	6.50572E-10	8.59278E-11

Table B13. Total Photodissociation Rate Coefficients for the Process $N_2O_5 + h\nu \rightarrow NO_2 + NO_2 + O$ for Wavelengths From 210 to 380 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+11	2.0E+11	5.0E+11	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14
1.0E+17	6.92337E-04	6.92337E-04	6.92336E-04	6.92334E-04	6.92331E-04	6.92323E-04	6.92309E-04	6.92281E-04	6.92198E-04	6.92059E-04
2.0E+17	6.92337E-04	6.92336E-04	6.92335E-04	6.92334E-04	6.92331E-04	6.92323E-04	6.92309E-04	6.92281E-04	6.92198E-04	6.92058E-04
5.0E+17	6.92336E-04	6.92336E-04	6.92335E-04	6.92333E-04	6.92331E-04	6.92322E-04	6.92308E-04	6.92280E-04	6.92197E-04	6.92058E-04
1.0E+18	6.92335E-04	6.92334E-04	6.92334E-04	6.92332E-04	6.92329E-04	6.92321E-04	6.92307E-04	6.92279E-04	6.92196E-04	6.92056E-04
2.0E+18	6.92332E-04	6.92332E-04	6.92331E-04	6.92330E-04	6.92327E-04	6.92319E-04	6.92305E-04	6.92277E-04	6.92193E-04	6.92054E-04
5.0E+18	6.92326E-04	6.92325E-04	6.92324E-04	6.92323E-04	6.92320E-04	6.92312E-04	6.92298E-04	6.92270E-04	6.92187E-04	6.92047E-04
1.0E+19	6.92314E-04	6.92314E-04	6.92313E-04	6.92312E-04	6.92309E-04	6.92300E-04	6.92287E-04	6.92259E-04	6.92175E-04	6.92036E-04
2.0E+19	6.92291E-04	6.92291E-04	6.92290E-04	6.92289E-04	6.92286E-04	6.92278E-04	6.92264E-04	6.92236E-04	6.92152E-04	6.92013E-04
5.0E+19	6.92223E-04	6.92222E-04	6.92222E-04	6.92220E-04	6.92217E-04	6.92209E-04	6.92195E-04	6.92167E-04	6.92084E-04	6.91944E-04
1.0E+20	6.92108E-04	6.92108E-04	6.92107E-04	6.92106E-04	6.92103E-04	6.92095E-04	6.92081E-04	6.92053E-04	6.91969E-04	6.91830E-04
2.0E+20	6.91880E-04	6.91880E-04	6.91879E-04	6.91877E-04	6.91875E-04	6.91866E-04	6.91852E-04	6.91824E-04	6.91741E-04	6.91602E-04
5.0E+20	6.91195E-04	6.91195E-04	6.91194E-04	6.91193E-04	6.91190E-04	6.91182E-04	6.91168E-04	6.91140E-04	6.91057E-04	6.90917E-04
1.0E+21	6.90058E-04	6.90057E-04	6.90057E-04	6.90055E-04	6.90052E-04	6.90044E-04	6.90030E-04	6.90002E-04	6.89919E-04	6.89780E-04
2.0E+21	6.87794E-04	6.87793E-04	6.87793E-04	6.87791E-04	6.87788E-04	6.87780E-04	6.87766E-04	6.87738E-04	6.87655E-04	6.87516E-04
5.0E+21	6.81093E-04	6.81093E-04	6.81092E-04	6.81090E-04	6.81088E-04	6.81079E-04	6.81066E-04	6.81038E-04	6.80955E-04	6.80817E-04
1.0E+22	6.70223E-04	6.70222E-04	6.70222E-04	6.70220E-04	6.70217E-04	6.70209E-04	6.70195E-04	6.70168E-04	6.70086E-04	6.69949E-04
2.0E+22	6.49550E-04	6.49550E-04	6.49549E-04	6.49548E-04	6.49545E-04	6.49537E-04	6.49524E-04	6.49497E-04	6.49416E-04	6.49281E-04
5.0E+22	5.95214E-04	5.95214E-04	5.95213E-04	5.95212E-04	5.95210E-04	5.95202E-04	5.95189E-04	5.95163E-04	5.95086E-04	5.94957E-04
1.0E+23	5.25402E-04	5.25402E-04	5.25401E-04	5.25400E-04	5.25398E-04	5.25390E-04	5.25378E-04	5.25354E-04	5.25281E-04	5.25160E-04
2.0E+23	4.37587E-04	4.37587E-04	4.37586E-04	4.37585E-04	4.37583E-04	4.37576E-04	4.37565E-04	4.37543E-04	4.37477E-04	4.37367E-04
5.0E+23	3.45059E-04	3.45059E-04	3.45059E-04	3.45058E-04	3.45056E-04	3.45050E-04	3.45041E-04	3.45022E-04	3.44965E-04	3.44870E-04
1.0E+24	3.16513E-04	3.16513E-04	3.16512E-04	3.16511E-04	3.16509E-04	3.16504E-04	3.16495E-04	3.16478E-04	3.16425E-04	3.16338E-04
2.0E+24	3.06849E-04	3.06849E-04	3.06848E-04	3.06847E-04	3.06846E-04	3.06840E-04	3.06832E-04	3.06815E-04	3.06765E-04	3.06681E-04
5.0E+24	3.02786E-04	3.02785E-04	3.02785E-04	3.02784E-04	3.02783E-04	3.02778E-04	3.02769E-04	3.02753E-04	3.02704E-04	3.02622E-04
1.0E+25	3.02285E-04	3.02285E-04	3.02284E-04	3.02283E-04	3.02282E-04	3.02277E-04	3.02269E-04	3.02252E-04	3.02203E-04	3.02121E-04
2.0E+25	3.02267E-04	3.02267E-04	3.02267E-04	3.02266E-04	3.02264E-04	3.02259E-04	3.02251E-04	3.02235E-04	3.02185E-04	3.02104E-04

Table B13. Total Photodissociation Rate Coefficients for the Process $N_2O_5 + h\nu \rightarrow NO_2 + NO_2 + O$ for Wavelengths From 210 to 380 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17
1.0E+17	6.91780E-04	6.90946E-04	6.89561E-04	6.86805E-04	6.78656E-04	7.72142E-07	7.67675E-07	7.54704E-07	7.34323E-07	6.97141E-07
2.0E+17	6.91780E-04	6.90946E-04	6.89561E-04	6.86805E-04	6.78656E-04	7.72129E-07	7.67662E-07	7.54692E-07	7.34311E-07	6.97129E-07
5.0E+17	6.91779E-04	6.90946E-04	6.89560E-04	6.86804E-04	6.78655E-04	7.72091E-07	7.67624E-07	7.54654E-07	7.34274E-07	6.97094E-07
1.0E+18	6.91778E-04	6.90944E-04	6.89559E-04	6.86803E-04	6.78654E-04	7.72028E-07	7.67561E-07	7.54592E-07	7.34214E-07	6.97036E-07
2.0E+18	6.91776E-04	6.90942E-04	6.89557E-04	6.86801E-04	6.78652E-04	7.71902E-07	7.67436E-07	7.54469E-07	7.34093E-07	6.96921E-07
5.0E+18	6.91769E-04	6.90935E-04	6.89550E-04	6.86794E-04	6.78645E-04	7.71529E-07	7.67064E-07	7.54102E-07	7.33735E-07	6.96579E-07
1.0E+19	6.91758E-04	6.90924E-04	6.89538E-04	6.86782E-04	6.78634E-04	7.70920E-07	7.66459E-07	7.53505E-07	7.33151E-07	6.96021E-07
2.0E+19	6.91735E-04	6.90901E-04	6.89516E-04	6.86760E-04	6.78611E-04	7.69752E-07	7.65296E-07	7.52358E-07	7.32030E-07	6.94950E-07
5.0E+19	6.91666E-04	6.90833E-04	6.89447E-04	6.86691E-04	6.78543E-04	7.66566E-07	7.62124E-07	7.49229E-07	7.28972E-07	6.92028E-07
1.0E+20	6.91552E-04	6.90718E-04	6.89333E-04	6.86577E-04	6.78430E-04	7.62013E-07	7.57592E-07	7.44758E-07	7.24601E-07	6.87850E-07
2.0E+20	6.91324E-04	6.90490E-04	6.89105E-04	6.86350E-04	6.78204E-04	7.54555E-07	7.50168E-07	7.37433E-07	7.17439E-07	6.81002E-07
5.0E+20	6.90639E-04	6.89806E-04	6.88422E-04	6.85668E-04	6.77526E-04	7.53788E-07	7.49405E-07	7.36686E-07	7.16715E-07	6.80321E-07
1.0E+21	6.89502E-04	6.88670E-04	6.87286E-04	6.84535E-04	6.76400E-04	7.36824E-07	7.32518E-07	7.20026E-07	7.00426E-07	6.64748E-07
2.0E+21	6.87239E-04	6.86408E-04	6.85027E-04	6.82280E-04	6.74158E-04	7.16305E-07	7.12093E-07	6.99879E-07	6.80733E-07	6.45925E-07
5.0E+21	6.80541E-04	6.79714E-04	6.78340E-04	6.75607E-04	6.67525E-04	6.84323E-07	6.80263E-07	6.68501E-07	6.50088E-07	6.16682E-07
1.0E+22	6.69675E-04	6.68855E-04	6.67492E-04	6.64781E-04	6.56765E-04	6.26879E-07	6.23086E-07	6.12112E-07	5.94981E-07	5.64024E-07
2.0E+22	6.49011E-04	6.48204E-04	6.46862E-04	6.44194E-04	6.36305E-04	5.56855E-07	5.53400E-07	5.43429E-07	5.27919E-07	5.00042E-07
5.0E+22	5.94699E-04	5.93926E-04	5.92642E-04	5.90089E-04	5.82543E-04	4.38888E-07	4.[illegible]054E-07	4.27910E-07	4.15340E-07	3.92990E-07
1.0E+23	5.24918E-04	5.24193E-04	5.22987E-04	5.20591E-04	5.13514E-04	2.72611E-07	2.70613E-07	2.64931E-07	2.56323E-07	2.41429E-07
2.0E+23	4.37147E-04	4.36488E-04	4.35394E-04	4.33218E-04	4.26798E-04	1.30307E-07	1.29099E-07	1.25731E-07	1.20814E-07	1.12767E-07
5.0E+23	3.44680E-04	3.44112E-04	3.43169E-04	3.41296E-04	3.35771E-04	3.79634E-08	3.73623E-08	3.57555E-08	3.35931E-08	3.05016E-08
1.0E+24	3.16163E-04	3.15639E-04	3.14769E-04	3.13042E-04	3.07949E-04	1.84099E-08	1.79518E-08	1.67513E-08	1.52016E-08	1.31551E-08
2.0E+24	3.06513E-04	3.06011E-04	3.05177E-04	3.03521E-04	2.98638E-04	1.77620E-08	1.73255E-08	1.61820E-08	1.47065E-08	1.27561E-08
5.0E+24	3.02457E-04	3.01966E-04	3.01150E-04	2.99528E-04	2.94749E-04	1.76841E-08	1.72539E-08	1.61266E-08	1.46702E-08	1.27403E-08
1.0E+25	3.01958E-04	3.01467E-04	3.00653E-04	2.99036E-04	2.94271E-04	1.76756E-08	1.72462E-08	1.61207E-08	1.46664E-08	1.27388E-08
2.0E+25	3.01940E-04	3.01450E-04	3.00636E-04	2.99019E-04	2.94254E-04	1.76753E-08	1.72459E-08	1.61205E-08	1.46663E-08	1.27387E-08

Table B13. Total Photodissociation Rate Coefficients for the Process $N_2O_5 + h\nu \rightarrow NO_2 + NO_2 + O$ for Wavelengths From 210 to 380 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19
1.0E+17	6.03763E-07	4.83551E-07	3.18465E-07	9.86375E-08	1.63090E-08
2.0E+17	6.03753E-07	4.83543E-07	3.18460E-07	9.86362E-08	1.63089E-08
5.0E+17	6.03723E-07	4.83519E-07	3.18444E-07	9.86322E-08	1.63084E-08
1.0E+18	6.03672E-07	4.83479E-07	3.18419E-07	9.86255E-08	1.63077E-08
2.0E+18	6.03572E-07	4.83399E-07	3.18368E-07	9.86123E-08	1.63062E-08
5.0E+18	6.03273E-07	4.83161E-07	3.18217E-07	9.85730E-08	1.63018E-08
1.0E+19	6.02787E-07	4.82774E-07	3.17971E-07	9.85087E-08	1.62946E-08
2.0E+19	6.01853E-07	4.82030E-07	3.17497E-07	9.83847E-08	1.62806E-08
5.0E+19	5.99303E-07	4.79995E-07	3.16199E-07	9.80421E-08	1.62413E-08
1.0E+20	5.95653E-07	4.77078E-07	3.14330E-07	9.75427E-08	1.61828E-08
2.0E+20	5.89662E-07	4.72279E-07	3.11242E-07	9.67042E-08	1.60817E-08
5.0E+20	5.89092E-07	4.71844E-07	3.10977E-07	9.66372E-08	1.60738E-08
1.0E+21	5.75467E-07	4.60915E-07	3.03913E-07	9.46837E-08	1.58296E-08
2.0E+21	5.59003E-07	4.47700E-07	2.95339E-07	9.22722E-08	1.55172E-08
5.0E+21	5.33511E-07	4.27298E-07	2.82119E-07	8.85198E-08	1.50175E-08
1.0E+22	4.87436E-07	3.90206E-07	2.57815E-07	8.13909E-08	1.40144E-08
2.0E+22	4.31625E-07	3.45375E-07	2.28419E-07	7.26317E-08	1.27358E-08
5.0E+22	3.38947E-07	2.71525E-07	1.80395E-07	5.83839E-08	1.06352E-08
1.0E+23	2.06846E-07	1.65135E-07	1.09845E-07	3.63482E-08	7.14610E-09
2.0E+23	9.55816E-08	7.61533E-08	5.11481E-08	1.79497E-08	4.17913E-09
5.0E+23	2.52507E-08	2.03050E-08	1.43418E-08	6.21662E-09	2.22475E-09
1.0E+24	1.02400E-08	8.04676E-09	5.85509E-09	3.22418E-09	1.67355E-09
2.0E+24	9.95878E-09	7.83253E-09	5.70855E-09	3.17142E-09	1.66353E-09
5.0E+24	9.95734E-09	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09
1.0E+25	9.95724E-09	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09
2.0E+25	9.95723E-09	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09

Table B14. Total Photodissociation Rate Coefficients for the Process $HNO_2 + h\nu \rightarrow OH + NO$ for Wavelengths From 300 to 390 nm

O3 COLUMN DENSITY	
1.0E+14	5.84756E-04
2.0E+14	5.84755E-04
5.0E+14	5.84754E-04
1.0E+15	5.84753E-04
2.0E+15	5.84749E-04
5.0E+15	5.84739E-04
1.0E+16	5.84722E-04
2.0E+16	5.84688E-04
5.0E+16	5.84585E-04
1.0E+17	5.84416E-04
2.0E+17	5.84083E-04
5.0E+17	5.83115E-04
1.0E+18	5.81605E-04
2.0E+18	5.78914E-04
5.0E+18	5.72656E-04
1.0E+19	5.65442E-04
2.0E+19	5.55729E-04
5.0E+19	5.37947E-04
1.0E+20	5.20145E-04
2.0E+20	4.99103E-04
5.0E+20	4.68331E-04
1.0E+21	4.43897E-04

Table B15. Total Photodissociation Rate Coefficients for the Process $HNO_3 + h\nu \rightarrow OH + NO_2$ for Wavelengths From 192 to 325 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+17	1.16539E-04	1.16539E-04	1.16539E-04	1.16537E-04	1.16535E-04	1.16528E-04	1.16516E-04	1.16493E-04	1.16424E-04	1.16309E-04
2.0E+17	1.16539E-04	1.16539E-04	1.16538E-04	1.16537E-04	1.16535E-04	1.16528E-04	1.16516E-04	1.16493E-04	1.16424E-04	1.16308E-04
5.0E+17	1.16539E-04	1.16539E-04	1.16538E-04	1.16537E-04	1.16534E-04	1.16528E-04	1.16516E-04	1.16493E-04	1.16423E-04	1.16308E-04
1.0E+18	1.16538E-04	1.16538E-04	1.16537E-04	1.16536E-04	1.16534E-04	1.16527E-04	1.16515E-04	1.16492E-04	1.16423E-04	1.16307E-04
2.0E+18	1.16537E-04	1.16537E-04	1.16536E-04	1.16535E-04	1.16532E-04	1.16525E-04	1.16514E-04	1.16491E-04	1.16421E-04	1.16306E-04
5.0E+18	1.16532E-04	1.16532E-04	1.16532E-04	1.16530E-04	1.16528E-04	1.16521E-04	1.16510E-04	1.16486E-04	1.16417E-04	1.16302E-04
1.0E+19	1.16525E-04	1.16525E-04	1.16524E-04	1.16523E-04	1.16521E-04	1.16514E-04	1.16502E-04	1.16479E-04	1.16410E-04	1.16295E-04
2.0E+19	1.16511E-04	1.16511E-04	1.16510E-04	1.16509E-04	1.16507E-04	1.16500E-04	1.16488E-04	1.16465E-04	1.16396E-04	1.16280E-04
5.0E+19	1.16469E-04	1.16469E-04	1.16468E-04	1.16467E-04	1.16465E-04	1.16458E-04	1.16446E-04	1.16423E-04	1.16354E-04	1.16238E-04
1.0E+20	1.16400E-04	1.16400E-04	1.16399E-04	1.16398E-04	1.16396E-04	1.16389E-04	1.16377E-04	1.16354E-04	1.16285E-04	1.16169E-04
2.0E+20	1.16265E-04	1.16265E-04	1.16264E-04	1.16263E-04	1.16261E-04	1.16254E-04	1.16242E-04	1.16219E-04	1.16150E-04	1.16035E-04
5.0E+20	1.16127E-04	1.16127E-04	1.16126E-04	1.16125E-04	1.16122E-04	1.16116E-04	1.16104E-04	1.16081E-04	1.16012E-04	1.15896E-04
1.0E+21	1.15652E-04	1.15652E-04	1.15652E-04	1.15650E-04	1.15648E-04	1.15641E-04	1.15630E-04	1.15606E-04	1.15537E-04	1.15422E-04
2.0E+21	1.14835E-04	1.14835E-04	1.14834E-04	1.14833E-04	1.14831E-04	1.14824E-04	1.14812E-04	1.14789E-04	1.14720E-04	1.14605E-04
5.0E+21	1.12858E-04	1.12857E-04	1.12857E-04	1.12856E-04	1.12853E-04	1.12846E-04	1.12835E-04	1.12812E-04	1.12743E-04	1.12629E-04
1.0E+22	1.09086E-04	1.09085E-04	1.09085E-04	1.09084E-04	1.09081E-04	1.09075E-04	1.09063E-04	1.09041E-04	1.08973E-04	1.08860E-04

Table B15. Total Photodissociation Rate Coefficients for the Process $HNO_3 + h\nu \rightarrow OH + NO_2$ for Wavelengths From 192 to 325 nm (Contd)

O2 COLUMN DENSITY \ O3 COLUMN DENSITY	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+17	1.16079E-04	1.15398E-04	1.14292E-04	1.12176E-04	1.06523E-04	9.89202E-05	8.80795E-05	6.98619E-05	5.31722E-05	3.41525E-05
2.0E+17	1.16079E-04	1.15398E-04	1.14292E-04	1.12176E-04	1.06523E-04	9.89201E-05	8.80794E-05	6.98618E-05	5.31721E-05	3.41525E-05
5.0E+17	1.16078E-04	1.15398E-04	1.14291E-04	1.12176E-04	1.06522E-04	9.89197E-05	8.80790E-05	6.98614E-05	5.31718E-05	3.41523E-05
1.0E+18	1.16078E-04	1.15397E-04	1.14290E-04	1.12175E-04	1.06522E-04	9.89190E-05	8.80784E-05	6.98609E-05	5.31713E-05	3.41520E-05
2.0E+18	1.16076E-04	1.15396E-04	1.14289E-04	1.12174E-04	1.06520E-04	9.89177E-05	8.80771E-05	6.98597E-05	5.31704E-05	3.41514E-05
5.0E+18	1.16072E-04	1.15391E-04	1.14285E-04	1.12169E-04	1.06516E-04	9.89136E-05	8.80733E-05	6.98564E-05	5.31677E-05	3.41495E-05
1.0E+19	1.16065E-04	1.15384E-04	1.14278E-04	1.12162E-04	1.06509E-04	9.89069E-05	8.80669E-05	6.98508E-05	5.31631E-05	3.41464E-05
2.0E+19	1.16051E-04	1.15370E-04	1.14264E-04	1.12148E-04	1.06495E-04	9.88935E-05	8.80541E-05	6.98396E-05	5.31540E-05	3.41402E-05
5.0E+19	1.16009E-04	1.15328E-04	1.14222E-04	1.12107E-04	1.06454E-04	9.88536E-05	8.80161E-05	6.98064E-05	5.31269E-05	3.41217E-05
1.0E+20	1.15940E-04	1.15260E-04	1.14153E-04	1.12038E-04	1.06387E-04	9.87880E-05	8.79536E-05	6.97518E-05	5.30825E-05	3.40914E-05
2.0E+20	1.15805E-04	1.15125E-04	1.14019E-04	1.11905E-04	1.06256E-04	9.86602E-05	8.78319E-05	6.96455E-05	5.29960E-05	3.40325E-05
5.0E+20	1.15667E-04	1.14987E-04	1.13882E-04	1.11769E-04	1.06124E-04	9.85336E-05	8.77152E-05	6.95513E-05	5.29266E-05	3.39918E-05
1.0E+21	1.15193E-04	1.14514E-04	1.13411E-04	1.11301E-04	1.05664E-04	9.80871E-05	8.72930E-05	6.91883E-05	5.26366E-05	3.37992E-05
2.0E+21	1.14377E-04	1.13700E-04	1.12599E-04	1.10494E-04	1.04873E-04	9.73209E-05	8.65711E-05	6.85728E-05	5.21498E-05	3.34803E-05
5.0E+21	1.12402E-04	1.11730E-04	1.10636E-04	1.08546E-04	1.02968E-04	9.54811E-05	8.48483E-05	6.71253E-05	5.10251E-05	3.27621E-05
1.0E+22	1.08636E-04	1.07971E-04	1.06890E-04	1.04826E-04	9.93215E-05	9.19509E-05	8.15257E-05	6.42989E-05	4.87946E-05	3.13045E-05

Table B20. Total Photodissociation Rate Coefficients for the Process $HO_2 + h\nu \rightarrow O_2 + H$ for Wavelengths From 180 to 274 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+17	1.12764E-03	1.11447E-03	1.09309E-03	1.05241E-03	9.45069E-04	8.04875E-04	6.17887E-04	3.63050E-04	2.08833E-04	9.88600E-05
2.0E+17	1.12762E-03	1.11445E-03	1.09307E-03	1.05239E-03	9.45050E-04	8.04857E-04	6.17870E-04	3.63037E-04	2.08824E-04	9.88554E-05
5.0E+17	1.12757E-03	1.11439E-03	1.09302E-03	1.05234E-03	9.44997E-04	8.04805E-04	6.17823E-04	3.62998E-04	2.08797E-04	9.88421E-05
1.0E+18	1.12748E-03	1.11431E-03	1.09293E-03	1.05226E-03	9.44916E-04	8.04728E-04	6.17751E-04	3.62940E-04	2.08757E-04	9.88220E-05
2.0E+18	1.12734E-03	1.11417E-03	1.09279E-03	1.05212E-03	9.44778E-04	8.04595E-04	6.17628E-04	3.62841E-04	2.08687E-04	9.87871E-05
5.0E+18	1.12691E-03	1.11384E-03	1.09247E-03	1.05179E-03	9.44463E-04	8.04292E-04	6.17346E-04	3.62614E-04	2.08526E-04	9.87059E-05
1.0E+19	1.12662E-03	1.11344E-03	1.09207E-03	1.05140E-03	9.44081E-04	8.03924E-04	6.17003E-04	3.62337E-04	2.08330E-04	9.86049E-05
2.0E+19	1.12604E-03	1.11287E-03	1.09150E-03	1.05083E-03	9.43523E-04	8.03387E-04	6.16506E-04	3.61934E-04	2.08042E-04	9.84546E-05
5.0E+19	1.12487E-03	1.11170E-03	1.09034E-03	1.04968E-03	9.42404E-04	8.02312E-04	6.15510E-04	3.61130E-04	2.07465E-04	9.81468E-05
1.0E+20	1.12355E-03	1.11039E-03	1.08903E-03	1.04838E-03	9.41138E-04	8.01099E-04	6.14391E-04	3.60232E-04	2.06818E-04	9.77951E-05
2.0E+20	1.12165E-03	1.10849E-03	1.08714E-03	1.04652E-03	9.39327E-04	7.99371E-04	6.12808E-04	3.58970E-04	2.05910E-04	9.72939E-05
5.0E+20	1.12007E-03	1.10692E-03	1.08559E-03	1.04500E-03	9.37898E-04	7.98076E-04	6.11722E-04	3.58261E-04	2.05491E-04	9.71014E-05
1.0E+21	1.11508E-03	1.10195E-03	1.08066E-03	1.04013E-03	9.33225E-04	7.93687E-04	6.07804E-04	3.55288E-04	2.03424E-04	9.59730E-05
2.0E+21	1.10762E-03	1.09454E-03	1.07330E-03	1.03290E-03	9.26328E-04	7.87288E-04	6.02206E-04	3.51219E-04	2.00694E-04	9.45129E-05
5.0E+21	1.08948E-03	1.07650E-03	1.05544E-03	1.01537E-03	9.09742E-04	7.72075E-04	5.89175E-04	3.42196E-04	1.94936E-04	9.15811E-05
1.0E+22	1.05983E-03	1.04702E-03	1.02624E-03	9.86722E-04	8.82631E-04	7.47200E-04	5.67849E-04	3.27368E-04	1.85390E-04	8.66197E-05
2.0E+22	1.00734E-03	9.94850E-04	9.74605E-04	9.36127E-04	8.34937E-04	7.03715E-04	5.30998E-04	3.02450E-04	1.69846E-04	7.88314E-05
5.0E+22	8.75153E-04	8.63526E-04	8.44722E-04	8.09046E-04	7.15656E-04	5.95698E-04	4.40585E-04	2.43079E-04	1.34025E-04	6.16213E-05
1.0E+23	7.01310E-04	6.90918E-04	6.74107E-04	6.42298E-04	5.59643E-04	4.55085E-04	3.23772E-04	1.67262E-04	8.83747E-05	3.93658E-05
2.0E+23	4.85107E-04	4.76452E-04	4.62485E-04	4.36185E-04	3.68712E-04	2.85655E-04	1.86793E-04	8.33320E-05	4.04439E-05	1.71553E-05
5.0E+23	2.50555E-04	2.44359E-04	2.34434E-04	2.15894E-04	1.69502E-04	1.15414E-04	5.79847E-05	1.45283E-05	5.33679E-06	2.20992E-06
1.0E+24	1.70615E-04	1.65677E-04	1.57771E-04	1.43098E-04	1.06935E-04	6.61750E-05	2.59885E-05	2.17455E-06	2.00761E-07	4.65079E-08
2.0E+24	1.42977E-04	1.38649E-04	1.31728E-04	1.18914E-04	8.75310E-05	5.26373E-05	1.92008E-05	1.01890E-06	1.52165E-08	2.52692E-09
5.0E+24	1.31568E-04	1.27536E-04	1.21090E-04	1.09166E-04	8.00283E-05	4.77828E-05	1.71599E-05	8.59583E-07	1.19301E-08	2.49510E-09
1.0E+25	1.30174E-04	1.26179E-04	1.19793E-04	1.07980E-04	7.91231E-05	4.72054E-05	1.69250E-05	8.43752E-07	1.17530E-08	2.49508E-09
2.0E+25	1.30125E-04	1.26131E-04	1.19747E-04	1.07939E-04	7.90911E-05	4.71850E-05	1.69167E-05	8.43194E-07	1.17468E-08	2.49508E-09

Table B20. Total Photodissociation Rate Coefficients for the Process $HO_2 + h\nu \rightarrow O_2 + H$ for Wavelengths From 180 to 274 nm

O2 COLUMN DENSITY \ O3 COLUMN DENSITY	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+17	1.13657E-03	1.13656E-03	1.13655E-03	1.13653E-03	1.13648E-03	1.13635E-03	1.13612E-03	1.13567E-03	1.13433E-03	1.13209E-03
2.0E+17	1.13655E-03	1.13654E-03	1.13653E-03	1.13651E-03	1.13646E-03	1.13633E-03	1.13610E-03	1.13565E-03	1.13431E-03	1.13207E-03
5.0E+17	1.13649E-03	1.13649E-03	1.13647E-03	1.13645E-03	1.13641E-03	1.13627E-03	1.13605E-03	1.13560E-03	1.13425E-03	1.13202E-03
1.0E+18	1.13641E-03	1.13640E-03	1.13639E-03	1.13637E-03	1.13632E-03	1.13619E-03	1.13596E-03	1.13551E-03	1.13417E-03	1.13193E-03
2.0E+18	1.13627E-03	1.13626E-03	1.13625E-03	1.13623E-03	1.13618E-03	1.13605E-03	1.13582E-03	1.13537E-03	1.13403E-03	1.13179E-03
5.0E+18	1.13594E-03	1.13593E-03	1.13592E-03	1.13590E-03	1.13585E-03	1.13572E-03	1.13549E-03	1.13504E-03	1.13370E-03	1.13146E-03
1.0E+19	1.13554E-03	1.13554E-03	1.13552E-03	1.13550E-03	1.13546E-03	1.13532E-03	1.13510E-03	1.13465E-03	1.13330E-03	1.13107E-03
2.0E+19	1.13496E-03	1.13496E-03	1.13494E-03	1.13492E-03	1.13488E-03	1.13474E-03	1.13452E-03	1.13407E-03	1.13272E-03	1.13049E-03
5.0E+19	1.13379E-03	1.13379E-03	1.13378E-03	1.13375E-03	1.13371E-03	1.13357E-03	1.13335E-03	1.13290E-03	1.13156E-03	1.12932E-03
1.0E+20	1.13247E-03	1.13246E-03	1.13245E-03	1.13243E-03	1.13238E-03	1.13225E-03	1.13202E-03	1.13158E-03	1.13023E-03	1.12800E-03
2.0E+20	1.13056E-03	1.13056E-03	1.13055E-03	1.13052E-03	1.13048E-03	1.13034E-03	1.13012E-03	1.12967E-03	1.12833E-03	1.12609E-03
5.0E+20	1.12898E-03	1.12897E-03	1.12896E-03	1.12894E-03	1.12889E-03	1.12876E-03	1.12853E-03	1.12808E-03	1.12674E-03	1.12451E-03
1.0E+21	1.12397E-03	1.12397E-03	1.12396E-03	1.12393E-03	1.12389E-03	1.12376E-03	1.12353E-03	1.12308E-03	1.12174E-03	1.11951E-03
2.0E+21	1.11649E-03	1.11649E-03	1.11648E-03	1.11645E-03	1.11641E-03	1.11628E-03	1.11605E-03	1.11561E-03	1.11427E-03	1.11205E-03
5.0E+21	1.09828E-03	1.09827E-03	1.09826E-03	1.09824E-03	1.09819E-03	1.09806E-03	1.09784E-03	1.09740E-03	1.09607E-03	1.09387E-03
1.0E+22	1.06851E-03	1.06851E-03	1.06850E-03	1.06847E-03	1.06843E-03	1.06830E-03	1.06808E-03	1.06764E-03	1.06633E-03	1.06416E-03
2.0E+22	1.01580E-03	1.01580E-03	1.01578E-03	1.01576E-03	1.01572E-03	1.01559E-03	1.01538E-03	1.01495E-03	1.01368E-03	1.01156E-03
5.0E+22	8.83007E-04	8.83003E-04	8.82991E-04	8.82971E-04	8.82932E-04	8.82813E-04	8.82614E-04	8.82218E-04	8.81031E-04	8.79058E-04
1.0E+23	7.08365E-04	7.08363E-04	7.08352E-04	7.08334E-04	7.08299E-04	7.08192E-04	7.08014E-04	7.07659E-04	7.06595E-04	7.04827E-04
2.0E+23	4.90993E-04	4.90990E-04	4.90981E-04	4.90967E-04	4.90937E-04	4.90848E-04	4.90699E-04	4.90403E-04	4.89515E-04	4.88040E-04
5.0E+23	2.54779E-04	2.54772E-04	2.54766E-04	2.54755E-04	2.54734E-04	2.54670E-04	2.54564E-04	2.54351E-04	2.53714E-04	2.52656E-04
1.0E+24	1.73989E-04	1.73987E-04	1.73982E-04	1.73974E-04	1.73957E-04	1.73905E-04	1.73820E-04	1.73650E-04	1.73140E-04	1.72294E-04
2.0E+24	1.45936E-04	1.45934E-04	1.45930E-04	1.45922E-04	1.45907E-04	1.45862E-04	1.45788E-04	1.45638E-04	1.45191E-04	1.44449E-04
5.0E+24	1.34326E-04	1.34325E-04	1.34321E-04	1.34314E-04	1.34300E-04	1.34258E-04	1.34188E-04	1.34049E-04	1.33632E-04	1.32941E-04
1.0E+25	1.32907E-04	1.32906E-04	1.32901E-04	1.32894E-04	1.32881E-04	1.32839E-04	1.32770E-04	1.32632E-04	1.32219E-04	1.31534E-04
2.0E+25	1.32857E-04	1.32855E-04	1.32851E-04	1.32844E-04	1.32830E-04	1.32789E-04	1.32720E-04	1.32582E-04	1.32169E-04	1.31484E-04

Table B19. Total Photodissociation Rate Coefficients for the Process $CH_2O + h\nu$ → $CHO + H$ and $CH_2O + h\nu$ → $CO + H_2$ for Wavelengths From 240 to 360 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18	5.0E+18
1.0E+13	2.58223E-04	2.57561E-04	2.56282E-04	2.52774E-04	2.47810E-04	2.40115E-04	2.25324E-04	2.10458E-04	1.92675E-04	1.66137E-04
2.0E+13	2.58223E-04	2.57561E-04	2.56282E-04	2.52774E-04	2.47810E-04	2.40115E-04	2.25324E-04	2.10458E-04	1.92675E-04	1.66137E-04
5.0E+13	2.58223E-04	2.57561E-04	2.56282E-04	2.52774E-04	2.47810E-04	2.40115E-04	2.25324E-04	2.10458E-04	1.92675E-04	1.66137E-04
1.0E+14	2.58222E-04	2.57560E-04	2.56281E-04	2.52773E-04	2.47809E-04	2.40114E-04	2.25324E-04	2.10458E-04	1.92675E-04	1.66137E-04
2.0E+14	2.58221E-04	2.57559E-04	2.56280E-04	2.52772E-04	2.47809E-04	2.40114E-04	2.25324E-04	2.10458E-04	1.92675E-04	1.66137E-04
5.0E+14	2.58219E-04	2.57556E-04	2.56278E-04	2.52770E-04	2.47806E-04	2.40112E-04	2.25323E-04	2.10457E-04	1.92675E-04	1.66137E-04
1.0E+15	2.58214E-04	2.57552E-04	2.56273E-04	2.52766E-04	2.47803E-04	2.40110E-04	2.25321E-04	2.10457E-04	1.92675E-04	1.66137E-04
2.0E+15	2.58205E-04	2.57543E-04	2.56265E-04	2.52758E-04	2.47796E-04	2.40104E-04	2.25319E-04	2.10456E-04	1.92675E-04	1.66137E-04
5.0E+15	2.58178E-04	2.57517E-04	2.56239E-04	2.52735E-04	2.47776E-04	2.40089E-04	2.25311E-04	2.10453E-04	1.92674E-04	1.66137E-04
1.0E+16	2.58135E-04	2.57474E-04	2.56198E-04	2.52697E-04	2.47743E-04	2.40064E-04	2.25299E-04	2.10447E-04	1.92672E-04	1.66137E-04
2.0E+16	2.58054E-04	2.57395E-04	2.56121E-04	2.52626E-04	2.47682E-04	2.40017E-04	2.25275E-04	2.10437E-04	1.92669E-04	1.66137E-04
5.0E+16	2.57850E-04	2.57193E-04	2.55925E-04	2.52446E-04	2.47525E-04	2.39895E-04	2.25211E-04	2.10408E-04	1.92659E-04	1.66136E-04
1.0E+17	2.57602E-04	2.56948E-04	2.55687E-04	2.52225E-04	2.47329E-04	2.39739E-04	2.25124E-04	2.10366E-04	1.92644E-04	1.66135E-04
2.0E+17	2.57296E-04	2.56645E-04	2.55390E-04	2.51946E-04	2.47076E-04	2.39529E-04	2.24991E-04	2.10293E-04	1.92615E-04	1.66132E-04
5.0E+17	2.56836E-04	2.56189E-04	2.54939E-04	2.51511E-04	2.46666E-04	2.39163E-04	2.24723E-04	2.10124E-04	1.92544E-04	1.66126E-04
1.0E+18	2.56368E-04	2.55722E-04	2.54476E-04	2.51060E-04	2.46234E-04	2.38765E-04	2.24414E-04	2.09920E-04	1.92454E-04	1.66119E-04
2.0E+18	2.55808E-04	2.55164E-04	2.53923E-04	2.50520E-04	2.45716E-04	2.38288E-04	2.24041E-04	2.09673E-04	1.92346E-04	1.66110E-04
5.0E+18	2.55285E-04	2.54644E-04	2.53407E-04	2.50017E-04	2.45233E-04	2.37844E-04	2.23695E-04	2.09444E-04	1.92246E-04	1.66101E-04
1.0E+19	2.55180E-04	2.54540E-04	2.53303E-04	2.49916E-04	2.45136E-04	2.37755E-04	2.23626E-04	2.09399E-04	1.92226E-04	1.66100E-04
2.0E+19	2.55168E-04	2.54528E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37745E-04	2.23618E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+19	2.55169E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+20	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
2.0E+20	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+20	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+21	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
2.0E+21	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+21	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45124E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+22	2.55167E-04	2.54527E-04	2.53290E-04	2.49904E-04	2.45124E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
2.0E+22	2.55167E-04	2.54526E-04	2.53290E-04	2.49903E-04	2.45124E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+22	2.55165E-04	2.54525E-04	2.53288E-04	2.49902E-04	2.45122E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+23	2.55162E-04	2.54522E-04	2.53286E-04	2.49900E-04	2.45122E-04	2.37743E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
2.0E+23	2.55157E-04	2.54517E-04	2.53282E-04	2.49897E-04	2.45120E-04	2.37742E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+23	2.55144E-04	2.54504E-04	2.53270E-04	2.49888E-04	2.45114E-04	2.37740E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+24	2.55127E-04	2.54488E-04	2.53255E-04	2.49877E-04	2.45107E-04	2.37737E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
2.0E+24	2.55106E-04	2.54468E-04	2.53237E-04	2.49863E-04	2.45098E-04	2.37733E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+24	2.55087E-04	2.54450E-04	2.53220E-04	2.49850E-04	2.45090E-04	2.37730E-04	2.23616E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+25	2.55084E-04	2.54447E-04	2.53218E-04	2.49848E-04	2.45089E-04	2.37730E-04	2.23616E-04	2.09393E-04	1.92224E-04	1.66099E-04

Table B19. Total Photodissociation Rate Coefficients for the Process $CH_2O + h\nu$ CHO + H and $CH_2O + h\nu \rightarrow CO + H_2$ for Wavelengths From 240 to 360 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15	2.0E+15
1.0E+13	2.58901E-04	2.58901E-04	2.58900E-04	2.58899E-04	2.58895E-04	2.58888E-04	2.58874E-04	2.58833E-04	2.58764E-04	2.58628E-04
2.0E+13	2.58901E-04	2.58901E-04	2.58900E-04	2.58899E-04	2.58895E-04	2.58888E-04	2.58874E-04	2.58833E-04	2.58764E-04	2.58628E-04
5.0E+13	2.58901E-04	2.58900E-04	2.58900E-04	2.58898E-04	2.58894E-04	2.58887E-04	2.58874E-04	2.58833E-04	2.58764E-04	2.58628E-04
1.0E+14	2.58900E-04	2.58900E-04	2.58899E-04	2.58898E-04	2.58894E-04	2.58887E-04	2.58873E-04	2.58832E-04	2.58764E-04	2.58627E-04
2.0E+14	2.58899E-04	2.58899E-04	2.58898E-04	2.58897E-04	2.58893E-04	2.58886E-04	2.58872E-04	2.58831E-04	2.58763E-04	2.58626E-04
5.0E+14	2.58897E-04	2.58896E-04	2.58896E-04	2.58894E-04	2.58890E-04	2.58883E-04	2.58869E-04	2.58828E-04	2.58760E-04	2.58624E-04
1.0E+15	2.58892E-04	2.58892E-04	2.58891E-04	2.58889E-04	2.58885E-04	2.58879E-04	2.58865E-04	2.58824E-04	2.58755E-04	2.58619E-04
2.0E+15	2.58883E-04	2.58882E-04	2.58882E-04	2.58880E-04	2.58876E-04	2.58869E-04	2.58856E-04	2.58814E-04	2.58746E-04	2.58610E-04
5.0E+15	2.58856E-04	2.58855E-04	2.58854E-04	2.58853E-04	2.58849E-04	2.58842E-04	2.58828E-04	2.58787E-04	2.58719E-04	2.58583E-04
1.0E+16	2.58812E-04	2.58811E-04	2.58811E-04	2.58809E-04	2.58805E-04	2.58798E-04	2.58785E-04	2.58744E-04	2.58675E-04	2.58539E-04
2.0E+16	2.58730E-04	2.58729E-04	2.58729E-04	2.58727E-04	2.58723E-04	2.58716E-04	2.58703E-04	2.58662E-04	2.58594E-04	2.58458E-04
5.0E+16	2.58523E-04	2.58522E-04	2.58522E-04	2.58520E-04	2.58516E-04	2.58509E-04	2.58496E-04	2.58455E-04	2.58387E-04	2.58252E-04
1.0E+17	2.58271E-04	2.58271E-04	2.58270E-04	2.58269E-04	2.58265E-04	2.58258E-04	2.58245E-04	2.58204E-04	2.58136E-04	2.58002E-04
2.0E+17	2.57962E-04	2.57961E-04	2.57961E-04	2.57959E-04	2.57955E-04	2.57949E-04	2.57935E-04	2.57895E-04	2.57828E-04	2.57694E-04
5.0E+17	2.57499E-04	2.57499E-04	2.57498E-04	2.57497E-04	2.57493E-04	2.57486E-04	2.57473E-04	2.57433E-04	2.57366E-04	2.57232E-04
1.0E+18	2.57029E-04	2.57028E-04	2.57028E-04	2.57026E-04	2.57022E-04	2.57016E-04	2.57002E-04	2.56962E-04	2.56895E-04	2.56763E-04
2.0E+18	2.56466E-04	2.56465E-04	2.56465E-04	2.56464E-04	2.56460E-04	2.56453E-04	2.56440E-04	2.56400E-04	2.56334E-04	2.56201E-04
5.0E+18	2.55942E-04	2.55941E-04	2.55941E-04	2.55939E-04	2.55935E-04	2.55929E-04	2.55915E-04	2.55876E-04	2.55809E-04	2.55677E-04
1.0E+19	2.55837E-04	2.55836E-04	2.55836E-04	2.55834E-04	2.55830E-04	2.55824E-04	2.55810E-04	2.55771E-04	2.55704E-04	2.55572E-04
2.0E+19	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
5.0E+19	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
1.0E+20	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
2.0E+20	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
5.0E+20	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
1.0E+21	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
2.0E+21	2.55824E-04	2.55823E-04	2.55823E-04	2.55821E-04	2.55817E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
5.0E+21	2.55824E-04	2.55823E-04	2.55823E-04	2.55821E-04	2.55817E-04	2.55811E-04	2.55797E-04	2.55758E-04	2.55691E-04	2.55559E-04
1.0E+22	2.55823E-04	2.55823E-04	2.55822E-04	2.55821E-04	2.55817E-04	2.55810E-04	2.55797E-04	2.55757E-04	2.55691E-04	2.55559E-04
2.0E+22	2.55823E-04	2.55822E-04	2.55822E-04	2.55820E-04	2.55816E-04	2.55810E-04	2.55797E-04	2.55757E-04	2.55690E-04	2.55559E-04
5.0E+22	2.55821E-04	2.55821E-04	2.55820E-04	2.55819E-04	2.55815E-04	2.55808E-04	2.55795E-04	2.55755E-04	2.55689E-04	2.55557E-04
1.0E+23	2.55818E-04	2.55818E-04	2.55817E-04	2.55816E-04	2.55812E-04	2.55805E-04	2.55792E-04	2.55752E-04	2.55686E-04	2.55554E-04
2.0E+23	2.55813E-04	2.55813E-04	2.55812E-04	2.55811E-04	2.55807E-04	2.55800E-04	2.55787E-04	2.55747E-04	2.55681E-04	2.55549E-04
5.0E+23	2.55799E-04	2.55799E-04	2.55798E-04	2.55797E-04	2.55793E-04	2.55786E-04	2.55773E-04	2.55733E-04	2.55667E-04	2.55535E-04
1.0E+24	2.55781E-04	2.55781E-04	2.55780E-04	2.55779E-04	2.55775E-04	2.55768E-04	2.55755E-04	2.55715E-04	2.55649E-04	2.55518E-04
2.0E+24	2.55759E-04	2.55759E-04	2.55758E-04	2.55757E-04	2.55753E-04	2.55746E-04	2.55733E-04	2.55693E-04	2.55627E-04	2.55496E-04
5.0E+24	2.55739E-04	2.55739E-04	2.55738E-04	2.55737E-04	2.55733E-04	2.55727E-04	2.55713E-04	2.55674E-04	2.55608E-04	2.55477E-04
1.0E+25	2.55737E-04	2.55736E-04	2.55736E-04	2.55734E-04	2.55730E-04	2.55724E-04	2.55710E-04	2.55671E-04	2.55605E-04	2.55474E-04

Table B18. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O$ for Wavelengths From 166 to 215 nm (Contd)

O2 COLUMN DENSITY \ O3 COLUMN DENSITY	5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20	5.0E+20	1.0E+21
1.0E+13	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+13	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+13	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+14	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+14	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+14	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+15	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+15	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+15	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+16	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+16	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+16	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+17	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+17	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+17	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+18	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+18	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+18	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+19	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+19	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+19	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+20	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+20	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+20	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+21	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+21	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+21	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+22	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+22	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+22	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+23	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+23	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+23	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+24	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+24	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153

Table B18. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O$ for Wavelengths From 166 to 215 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+13	8.23559E-09	8.21569E-09	8.18264E-09	8.11694E-09	7.92300E-09	7.61006E-09	7.02095E-09	5.51462E-09	3.69031E-09	1.65855E-09
2.0E+13	8.23553E-09	8.21563E-09	8.18258E-09	8.11688E-09	7.92294E-09	7.61000E-09	7.02090E-09	5.51458E-09	3.69028E-09	1.65854E-09
5.0E+13	8.23535E-09	8.21546E-09	8.18241E-09	8.11671E-09	7.92277E-09	7.60984E-09	7.02075E-09	5.51446E-09	3.69021E-09	1.65850E-09
1.0E+14	8.23506E-09	8.21516E-09	8.18211E-09	8.11642E-09	7.92249E-09	7.60957E-09	7.02050E-09	5.51427E-09	3.69008E-09	1.65845E-09
2.0E+14	8.23447E-09	8.21457E-09	8.18153E-09	8.11584E-09	7.92192E-09	7.60902E-09	7.02000E-09	5.51388E-09	3.68982E-09	1.65833E-09
5.0E+14	8.23270E-09	8.21281E-09	8.17977E-09	8.11409E-09	7.92022E-09	7.60739E-09	7.01849E-09	5.51270E-09	3.68903E-09	1.65799E-09
1.0E+15	8.22975E-09	8.20987E-09	8.17684E-09	8.11119E-09	7.91739E-09	7.60467E-09	7.01599E-09	5.51074E-09	3.68773E-09	1.65741E-09
2.0E+15	8.22386E-09	8.20400E-09	8.17099E-09	8.10538E-09	7.91172E-09	7.59923E-09	7.01098E-09	5.50682E-09	3.68513E-09	1.65626E-09
5.0E+15	8.20623E-09	8.18641E-09	8.15347E-09	8.08801E-09	7.89477E-09	7.58296E-09	6.99598E-09	5.49508E-09	3.67733E-09	1.65282E-09
1.0E+16	8.17696E-09	8.15721E-09	8.12440E-09	8.05917E-09	7.86663E-09	7.55595E-09	6.97109E-09	5.47561E-09	3.66439E-09	1.64711E-09
2.0E+16	8.11889E-09	8.09928E-09	8.06670E-09	8.00194E-09	7.81079E-09	7.50234E-09	6.92170E-09	5.43696E-09	3.63871E-09	1.63577E-09
5.0E+16	7.94821E-09	7.92902E-09	7.89714E-09	7.83376E-09	7.64668E-09	7.34481E-09	6.77654E-09	5.32339E-09	3.56326E-09	1.60246E-09
1.0E+17	7.67522E-09	7.65670E-09	7.62593E-09	7.56476E-09	7.38421E-09	7.09286E-09	6.54437E-09	5.14173E-09	3.44258E-09	1.54920E-09
2.0E+17	7.15081E-09	7.13357E-09	7.10493E-09	7.04801E-09	6.87997E-09	6.60881E-09	6.09833E-09	4.79270E-09	3.21064E-09	1.44677E-09
5.0E+17	5.85974E-09	5.84567E-09	5.82229E-09	5.77581E-09	5.63861E-09	5.41720E-09	5.00030E-09	3.93360E-09	2.63989E-09	1.19483E-09
1.0E+18	4.38135E-09	4.37090E-09	4.35355E-09	4.31905E-09	4.21719E-09	4.05279E-09	3.74314E-09	2.95019E-09	1.98678E-09	9.06714E-10
2.0E+18	2.83407E-09	2.82743E-09	2.81639E-09	2.79445E-09	2.72966E-09	2.62504E-09	2.42783E-09	1.92180E-09	1.30434E-09	6.06123E-10
5.0E+18	1.55073E-09	1.54725E-09	1.54147E-09	1.52998E-09	1.49604E-09	1.44116E-09	1.33751E-09	1.07004E-09	7.39870E-10	3.58122E-10
1.0E+19	1.14257E-09	1.14010E-09	1.13598E-09	1.12780E-09	1.10361E-09	1.06448E-09	9.90439E-10	7.98532E-10	5.59504E-10	2.78444E-10
2.0E+19	9.20991E-10	9.19045E-10	9.15810E-10	9.09377E-10	8.90355E-10	8.59560E-10	8.01226E-10	6.49564E-10	4.59465E-10	2.33258E-10
5.0E+19	7.11624E-10	7.10164E-10	7.07738E-10	7.02911E-10	6.88636E-10	6.65510E-10	6.21645E-10	5.07214E-10	3.62768E-10	1.88543E-10
1.0E+20	5.73567E-10	5.72422E-10	5.70518E-10	5.66731E-10	5.55524E-10	5.37359E-10	5.02866E-10	4.12617E-10	2.97993E-10	1.58086E-10
2.0E+20	4.47148E-10	4.46286E-10	4.44854E-10	4.42003E-10	4.33565E-10	4.19877E-10	3.93849E-10	3.25484E-10	2.37963E-10	1.29490E-10
5.0E+20	4.46927E-10	4.46066E-10	4.44634E-10	4.41784E-10	4.33350E-10	4.19669E-10	3.93652E-10	3.25319E-10	2.37839E-10	1.29419E-10
1.0E+21	3.08433E-10	3.07875E-10	3.06947E-10	3.05101E-10	2.99633E-10	2.90751E-10	2.73817E-10	2.29036E-10	1.70898E-10	9.68980E-11
2.0E+21	2.34369E-10	2.33967E-10	2.33299E-10	2.31968E-10	2.28025E-10	2.21612E-10	2.09361E-10	1.76783E-10	1.34005E-10	7.83751E-11
5.0E+21	1.84499E-10	1.84196E-10	1.83691E-10	1.82687E-10	1.79710E-10	1.74864E-10	1.65593E-10	1.40837E-10	1.08055E-10	6.47265E-11
1.0E+22	1.41710E-10	1.41484E-10	1.41109E-10	1.40362E-10	1.38148E-10	1.34542E-10	1.27637E-10	1.09152E-10	8.45402E-11	5.16358E-11
2.0E+22	1.15859E-10	1.15677E-10	1.15373E-10	1.14768E-10	1.12973E-10	1.10051E-10	1.04455E-10	8.94741E-11	6.95121E-11	4.27606E-11
5.0E+22	8.48856E-11	8.47527E-11	8.45316E-11	8.40914E-11	8.27862E-11	8.06608E-11	7.65907E-11	6.56940E-11	5.11706E-11	3.16775E-11
1.0E+23	4.98125E-11	4.97335E-11	4.96020E-11	4.93402E-11	4.85642E-11	4.73012E-11	4.48846E-11	3.84294E-11	2.98619E-11	1.84374E-11
2.0E+23	2.07956E-11	2.07625E-11	2.07075E-11	2.05980E-11	2.02734E-11	1.97452E-11	1.87351E-11	1.60400E-11	1.24702E-11	7.72202E-12
5.0E+23	3.00891E-12	3.00448E-12	2.99711E-12	2.98243E-12	2.93890E-12	2.86802E-12	2.73219E-12	2.36794E-12	1.88005E-12	1.21561E-12
1.0E+24	4.35417E-13	4.34426E-13	4.32780E-13	4.29508E-13	4.19844E-13	4.04232E-13	3.74777E-13	2.99008E-13	2.06060E-13	9.97381E-14
2.0E+24	3.94567E-13	3.93629E-13	3.92071E-13	3.88973E-13	3.79825E-13	3.65056E-13	3.37227E-13	2.65877E-13	1.79013E-13	8.13910E-14

Table B18. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O$ for Wavelengths From 166 to 215 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+13	8.24887E-09	8.24886E-09	8.24884E-09	8.24881E-09	8.24875E-09	8.24855E-09	8.24821E-09	8.24755E-09	8.24555E-09	8.24223E-09
2.0E+13	8.24881E-09	8.24881E-09	8.24879E-09	8.24875E-09	8.24869E-09	8.24849E-09	8.24815E-09	8.24749E-09	8.24549E-09	8.24217E-09
5.0E+13	8.24864E-09	8.24863E-09	8.24861E-09	8.24858E-09	8.24851E-09	8.24831E-09	8.24798E-09	8.24731E-09	8.24532E-09	8.24199E-09
1.0E+14	8.24834E-09	8.24833E-09	8.24831E-09	8.24828E-09	8.24821E-09	8.24801E-09	8.24768E-09	8.24702E-09	8.24502E-09	8.24170E-09
2.0E+14	8.24775E-09	8.24774E-09	8.24772E-09	8.24769E-09	8.24762E-09	8.24742E-09	8.24709E-09	8.24643E-09	8.24443E-09	8.24111E-09
5.0E+14	8.24598E-09	8.24597E-09	8.24595E-09	8.24592E-09	8.24585E-09	8.24565E-09	8.24532E-09	8.24465E-09	8.24266E-09	8.23934E-09
1.0E+15	8.24303E-09	8.24302E-09	8.24300E-09	8.24297E-09	8.24290E-09	8.24270E-09	8.24237E-09	8.24170E-09	8.23971E-09	8.23639E-09
2.0E+15	8.23713E-09	8.23712E-09	8.23710E-09	8.23707E-09	8.23700E-09	8.23680E-09	8.23647E-09	8.23580E-09	8.23381E-09	8.23049E-09
5.0E+15	8.21947E-09	8.21946E-09	8.21944E-09	8.21941E-09	8.21934E-09	8.21914E-09	8.21881E-09	8.21815E-09	8.21616E-09	8.21285E-09
1.0E+16	8.19015E-09	8.19015E-09	8.19013E-09	8.19009E-09	8.19003E-09	8.18983E-09	8.18950E-09	8.18884E-09	8.18686E-09	8.18356E-09
2.0E+16	8.13198E-09	8.13197E-09	8.13195E-09	8.13192E-09	8.13185E-09	8.13166E-09	8.13133E-09	8.13067E-09	8.12871E-09	8.12543E-09
5.0E+16	7.96102E-09	7.96102E-09	7.96100E-09	7.96097E-09	7.96090E-09	7.96071E-09	7.96039E-09	7.95975E-09	7.95782E-09	7.95462E-09
1.0E+17	7.68759E-09	7.68758E-09	7.68756E-09	7.68753E-09	7.68747E-09	7.68729E-09	7.68698E-09	7.68636E-09	7.68450E-09	7.68141E-09
2.0E+17	7.16231E-09	7.16231E-09	7.16229E-09	7.16226E-09	7.16220E-09	7.16203E-09	7.16174E-09	7.16117E-09	7.15944E-09	7.15656E-09
5.0E+17	5.86913E-09	5.86913E-09	5.86912E-09	5.86909E-09	5.86905E-09	5.86890E-09	5.86867E-09	5.86820E-09	5.86679E-09	5.86444E-09
1.0E+18	4.38832E-09	4.38832E-09	4.38831E-09	4.38829E-09	4.38826E-09	4.38815E-09	4.38798E-09	4.38763E-09	4.38658E-09	4.38484E-09
2.0E+18	2.83851E-09	2.83851E-09	2.83850E-09	2.83849E-09	2.83847E-09	2.83840E-09	2.83829E-09	2.83807E-09	2.83740E-09	2.83629E-09
5.0E+18	1.55305E-09	1.55305E-09	1.55304E-09	1.55304E-09	1.55303E-09	1.55299E-09	1.55293E-09	1.55282E-09	1.55247E-09	1.55189E-09
1.0E+19	1.14423E-09	1.14423E-09	1.14422E-09	1.14422E-09	1.14421E-09	1.14419E-09	1.14415E-09	1.14406E-09	1.14381E-09	1.14340E-09
2.0E+19	9.22290E-10	9.22289E-10	9.22287E-10	9.22284E-10	9.22278E-10	9.22258E-10	9.22225E-10	9.22160E-10	9.21965E-10	9.21640E-10
5.0E+19	7.12598E-10	7.12597E-10	7.12596E-10	7.12594E-10	7.12589E-10	7.12574E-10	7.12550E-10	7.12501E-10	7.12355E-10	7.12111E-10
1.0E+20	5.74333E-10	5.74331E-10	5.74330E-10	5.74328E-10	5.74325E-10	5.74313E-10	5.74294E-10	5.74256E-10	5.74141E-10	5.73950E-10
2.0E+20	4.47723E-10	4.47723E-10	4.47722E-10	4.47721E-10	4.47718E-10	4.47709E-10	4.47695E-10	4.47666E-10	4.47580E-10	4.47436E-10
5.0E+20	4.47502E-10	4.47502E-10	4.47501E-10	4.47500E-10	4.47497E-10	4.47488E-10	4.47474E-10	4.47445E-10	4.47359E-10	4.47215E-10
1.0E+21	3.08805E-10	3.08805E-10	3.08804E-10	3.08803E-10	3.08802E-10	3.08796E-10	3.08787E-10	3.08768E-10	3.08712E-10	3.08619E-10
2.0E+21	2.34638E-10	2.34637E-10	2.34637E-10	2.34636E-10	2.34635E-10	2.34631E-10	2.34624E-10	2.34611E-10	2.34571E-10	2.34504E-10
5.0E+21	1.84702E-10	1.84702E-10	1.84701E-10	1.84701E-10	1.84700E-10	1.84697E-10	1.84692E-10	1.84681E-10	1.84651E-10	1.84600E-10
1.0E+22	1.41860E-10	1.41860E-10	1.41860E-10	1.41860E-10	1.41859E-10	1.41857E-10	1.41853E-10	1.41845E-10	1.41823E-10	1.41785E-10
2.0E+22	1.15981E-10	1.15981E-10	1.15981E-10	1.15981E-10	1.15980E-10	1.15978E-10	1.15975E-10	1.15969E-10	1.15951E-10	1.15920E-10
5.0E+22	8.49743E-11	8.49743E-11	8.49741E-11	8.49739E-11	8.49735E-11	8.49721E-11	8.49699E-11	8.49655E-11	8.49522E-11	8.49300E-11
1.0E+23	4.98653E-11	4.98653E-11	4.98652E-11	4.98651E-11	4.98648E-11	4.98640E-11	4.98627E-11	4.98601E-11	4.98521E-11	4.98389E-11
2.0E+23	2.08177E-11	2.08176E-11	2.08176E-11	2.08176E-11	2.08174E-11	2.08171E-11	2.08166E-11	2.08155E-11	2.08121E-11	2.08066E-11
5.0E+23	3.01187E-12	3.01186E-12	3.01186E-12	3.01185E-12	3.01184E-12	3.01179E-12	3.01172E-12	3.01157E-12	3.01113E-12	3.01039E-12
1.0E+24	4.36078E-13	4.36078E-13	4.36077E-13	4.36075E-13	4.36072E-13	4.36062E-13	4.36045E-13	4.36012E-13	4.35913E-13	4.35747E-13
2.0E+24	3.95193E-13	3.95193E-13	3.95192E-13	3.95190E-13	3.95187E-13	3.95178E-13	3.95162E-13	3.95131E-13	3.95037E-13	3.94880E-13

Table B17. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O(^1D)$ for Wavelengths From 116.2 to 166 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY								
	5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20
1.0E+13	1.44282E-08	6.24892E-09	1.78563E-09	8.73281E-11	8.97046E-13	1.29487E-16	6.18488E-28	9.65893E-47	2.37149E-84
2.0E+13	1.44273E-08	6.24861E-09	1.78556E-09	8.73257E-11	8.97025E-13	1.29484E-16	6.18475E-28	9.65873E-47	2.37144E-84
5.0E+13	1.44245E-08	6.24766E-09	1.78536E-09	8.73182E-11	8.96959E-13	1.29476E-16	6.18436E-28	9.65812E-47	2.37129E-84
1.0E+14	1.44198E-08	6.24608E-09	1.78502E-09	8.73058E-11	8.96849E-13	1.29461E-16	6.18371E-28	9.65712E-47	2.37104E-84
2.0E+14	1.44104E-08	6.24293E-09	1.78433E-09	8.72810E-11	8.96630E-13	1.29433E-16	6.18243E-28	9.65511E-47	2.37055E-84
5.0E+14	1.43823E-08	6.23348E-09	1.78228E-09	8.72066E-11	8.95973E-13	1.29348E-16	6.17856E-28	9.64909E-47	2.36907E-84
1.0E+15	1.43356E-08	6.21777E-09	1.77887E-09	8.70829E-11	8.94879E-13	1.29205E-16	6.17212E-28	9.63906E-47	2.36661E-84
2.0E+15	1.42429E-08	6.18650E-09	1.77208E-09	8.68360E-11	8.92695E-13	1.28921E-16	6.15927E-28	9.61903E-47	2.36169E-84
5.0E+15	1.39692E-08	6.09393E-09	1.75189E-09	8.60999E-11	8.86177E-13	1.28073E-16	6.12087E-28	9.55919E-47	2.34700E-84
1.0E+16	1.35281E-08	5.94358E-09	1.71889E-09	8.48891E-11	8.75429E-13	1.26673E-16	6.05741E-28	9.46029E-47	2.32272E-84
2.0E+16	1.26987E-08	5.65705E-09	1.65517E-09	8.25252E-11	8.54351E-13	1.23919E-16	5.93245E-28	9.26555E-47	2.27491E-84
5.0E+16	1.05782E-08	4.89851E-09	1.48097E-09	7.58722E-11	7.94332E-13	1.16022E-16	5.57285E-28	8.70504E-47	2.13729E-84
1.0E+17	7.97646E-09	3.90476E-09	1.23854E-09	6.60946E-11	7.04143E-13	1.03993E-16	5.02135E-28	7.84520E-47	1.92618E-84
2.0E+17	4.87398E-09	2.58936E-09	8.85155E-10	5.05224E-11	5.55023E-13	8.36308E-17	4.07685E-28	6.37192E-47	1.56446E-84
5.0E+17	1.62428E-09	9.52031E-10	3.65897E-10	2.36286E-11	2.77408E-13	4.37894E-17	2.18249E-28	3.41404E-47	8.38231E-85
1.0E+18	4.54105E-10	2.58205E-10	1.04641E-10	7.34631E-12	9.15228E-14	1.51281E-17	7.70764E-29	1.20671E-47	2.96277E-85
2.0E+18	8.08768E-11	2.89490E-11	1.13689E-11	8.34787E-13	1.08426E-14	1.85701E-18	9.62304E-30	1.50754E-48	3.70139E-86
5.0E+18	1.89959E-11	1.01080E-12	2.41356E-14	1.57727E-15	2.07641E-17	3.59944E-21	1.87595E-32	2.93947E-51	7.21718E-89
1.0E+19	8.09561E-12	4.35638E-13	1.41722E-15	4.80283E-20	6.31712E-22	1.09529E-25	5.70897E-37	8.94555E-56	2.19637E-93
2.0E+19	2.38741E-12	1.22251E-13	4.06649E-16	1.63975E-23	5.85059E-31	1.01439E-34	5.28729E-46	8.28480E-65	2.03413-102
5.0E+19	2.84047E-13	5.74015E-15	1.43921E-17	5.76535E-25	2.94718E-37	1.57837E-61	4.20008E-73	6.58122E-92	1.61586-129
1.0E+20	1.07654E-13	6.66417E-16	3.14633E-19	2.36667E-27	1.20319E-39	3.15692E-64	2.86175-118	4.48415-137	1.10098-174
2.0E+20	3.14917E-14	8.63465E-17	3.49187E-20	2.43571E-30	2.01228E-44	5.27258E-69	9.52402-143	2.08175-227	5.11123-265
5.0E+20	1.36298E-15	2.23290E-19	8.63655E-23	5.94019E-33	6.85986E-50	3.37128E-83	4.43713-157	5.51778-280	0.
1.0E+21	9.11393E-18	9.31033E-23	3.92055E-27	2.69684E-37	3.11437E-54	4.15337E-88	5.76641-181	0.	0.
2.0E+21	4.13750E-22	3.79249E-27	8.39948E-36	5.55861E-46	6.41920E-63	8.56074E-97	2.03050-198	0.	0.
5.0E+21	3.87172E-35	3.54885E-40	2.98165E-50	4.86740E-72	5.62098E-89	7.49622-123	1.77801-224	0.	0.
1.0E+22	7.46758E-57	6.84485E-62	5.75085E-72	3.41064-102	2.09105-132	2.78865-166	6.61433-268	0.	0.
2.0E+22	2.77800-100	2.54634-105	2.13936-115	1.26878-145	5.31163-196	3.85921-253	0.	0.	0.
5.0E+22	1.43017-230	1.31090-235	1.10139-245	6.53196-276	0.	0.	0.	0.	0.

Table B17. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O(^1D)$ for Wavelengths From 116.2 to 166 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17
1.0E+13	8.82221E-08	8.79581E-08	8.75211E-08	8.66585E-08	8.41591E-08	8.02701E-08	7.34105E-08	5.83252E-08	4.37704E-08	2.98301E-08
2.0E+13	8.82167E-08	8.79527E-08	8.75157E-08	8.66532E-08	8.41539E-08	8.02650E-08	7.34056E-08	5.83210E-08	4.37669E-08	2.98278E-08
5.0E+13	8.82006E-08	8.79366E-08	8.74997E-08	8.66372E-08	8.41381E-08	8.02496E-08	7.33910E-08	5.83082E-08	4.37567E-08	2.98208E-08
1.0E+14	8.81738E-08	8.79098E-08	8.74730E-08	8.66107E-08	8.41119E-08	8.02240E-08	7.33666E-08	5.82870E-08	4.37395E-08	2.98091E-08
2.0E+14	8.81202E-08	8.78563E-08	8.74196E-08	8.65575E-08	8.40596E-08	8.01729E-08	7.33179E-08	5.82446E-08	4.37053E-08	2.97857E-08
5.0E+14	8.79597E-08	8.76960E-08	8.72597E-08	8.63984E-08	8.39028E-08	8.00200E-08	7.31721E-08	5.81176E-08	4.35028E-08	2.97157E-08
1.0E+15	8.76933E-08	8.74301E-08	8.69944E-08	8.61344E-08	8.36427E-08	7.97661E-08	7.29302E-08	5.79069E-08	4.34327E-08	2.95996E-08
2.0E+15	8.71649E-08	8.69024E-08	8.64681E-08	8.56107E-08	8.31267E-08	7.92625E-08	7.24502E-08	5.74889E-08	4.30952E-08	2.93691E-08
5.0E+15	8.56136E-08	8.53534E-08	8.49229E-08	8.40732E-08	8.16116E-08	7.77840E-08	7.10409E-08	5.62614E-08	4.21037E-08	2.86911E-08
1.0E+16	8.31372E-08	8.28807E-08	8.24563E-08	8.16187E-08	7.91930E-08	7.54235E-08	6.87908E-08	5.43007E-08	4.05187E-08	2.76052E-08
2.0E+16	7.85653E-08	7.83156E-08	7.79024E-08	7.70871E-08	7.47276E-08	7.10652E-08	6.46355E-08	5.06776E-08	3.75855E-08	2.55877E-08
5.0E+16	6.74127E-08	6.71794E-08	6.67935E-08	6.60325E-08	6.38334E-08	6.04304E-08	5.44922E-08	4.18188E-08	3.03855E-08	2.05860E-08
1.0E+17	5.49301E-08	5.47151E-08	5.43595E-08	5.36587E-08	5.16375E-08	4.85219E-08	4.31265E-08	3.18623E-08	2.22316E-08	1.48077E-08
2.0E+17	4.21191E-08	4.19228E-08	4.15984E-08	4.09596E-08	3.91210E-08	3.62994E-08	3.14552E-08	2.15994E-08	1.37268E-08	8.57459E-09
5.0E+17	3.12219E-08	3.10436E-08	3.07491E-08	3.01694E-08	2.85041E-08	2.59585E-08	2.16222E-08	1.30026E-08	6.54646E-09	3.04871E-09
1.0E+18	2.69793E-08	2.68113E-08	2.65338E-08	2.59879E-08	2.44211E-08	2.20304E-08	1.79729E-08	9.99335E-09	4.18178E-09	1.27610E-09
2.0E+18	2.42727E-08	2.41140E-08	2.38519E-08	2.33365E-08	2.18582E-08	1.96063E-08	1.57966E-08	8.37242E-09	3.09299E-09	6.20073E-10
5.0E+18	2.16428E-08	2.14958E-08	2.12531E-08	2.07760E-08	1.94088E-08	1.73297E-08	1.38239E-08	7.05849E-09	2.37318E-09	3.42583E-10
1.0E+19	1.99580E-08	1.98205E-08	1.95934E-08	1.91471E-08	1.78686E-08	1.59254E-08	1.26528E-08	6.36014E-09	2.04692E-09	2.40989E-10
2.0E+19	1.78972E-08	1.77733E-08	1.75687E-08	1.71666E-08	1.60146E-08	1.42642E-08	1.13171E-08	5.65592E-09	1.78723E-09	1.86582E-10
5.0E+19	1.32281E-08	1.31364E-08	1.29850E-08	1.26873E-08	1.18346E-08	1.05388E-08	8.35753E-09	4.16853E-09	1.30843E-09	1.29718E-10
1.0E+20	8.02109E-09	7.96546E-09	7.87361E-09	7.69307E-09	7.17592E-09	6.39010E-09	5.06723E-09	2.52684E-09	7.92565E-10	7.81748E-11
2.0E+20	2.95034E-09	2.92988E-09	2.89609E-09	2.82968E-09	2.63944E-09	2.35037E-09	1.86375E-09	9.29273E-10	2.91368E-10	2.86697E-11
5.0E+20	1.46878E-10	1.45860E-10	1.44178E-10	1.40871E-10	1.31400E-10	1.17008E-10	9.27814E-11	4.62587E-11	1.45016E-11	1.42521E-12
1.0E+21	9.89656E-13	9.82792E-13	9.71457E-13	9.49179E-13	8.85363E-13	7.88393E-13	6.25154E-13	3.11686E-13	9.77094E-14	9.60225E-15
2.0E+21	4.49303E-17	4.46187E-17	4.41041E-17	4.30927E-17	4.01954E-17	3.57930E-17	2.83819E-17	1.41505E-17	4.43600E-18	4.35941E-19
5.0E+21	4.20441E-30	4.17525E-30	4.12709E-30	4.03245E-30	3.76133E-30	3.34937E-30	2.65587E-30	1.32415E-30	4.15104E-31	4.07937E-32
1.0E+22	8.10925E-52	8.05301E-52	7.96013E-52	7.77758E-52	7.25467E-52	6.46011E-52	5.12252E-52	2.55396E-52	8.00632E-53	7.86809E-54
2.0E+22	3.01670E-95	2.99578E-95	2.96123E-95	2.89332E-95	2.69879E-95	2.40321E-95	1.90561E-95	9.50093E-96	2.97841E-96	2.92699E-97
5.0E+22	1.55306-225	1.54229-225	1.52450-225	1.48954-225	1.38939-225	1.23722-225	9.81049-226	4.89127-226	1.53335-226	1.50687-227

Table B17. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O(^1D)$ for Wavelengths From 116.2 to 166 nm

O2 COLUMN DENSITY \ O3 COLUMN DENSITY	1.0E+11	2.0E+11	5.0E+11	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14
1.0E+13	8.83988E-08	8.83987E-08	8.83984E-08	8.83980E-08	8.83971E-08	8.83945E-08	8.83900E-08	8.83812E-08	8.83546E-08	8.83104E-08
2.0E+13	8.83934E-08	8.83933E-08	8.83931E-08	8.83926E-08	8.83917E-08	8.83891E-08	8.83847E-08	8.83758E-08	8.83493E-08	8.83050E-08
5.0E+13	8.83773E-08	8.83772E-08	8.83769E-08	8.83765E-08	8.83756E-08	8.83730E-08	8.83685E-08	8.83597E-08	8.83331E-08	8.82889E-08
1.0E+14	8.83504E-08	8.83504E-08	8.83501E-08	8.83496E-08	8.83488E-08	8.83461E-08	8.83417E-08	8.83328E-08	8.83063E-08	8.82621E-08
2.0E+14	8.82968E-08	8.82967E-08	8.82964E-08	8.82960E-08	8.82951E-08	8.82924E-08	8.82880E-08	8.82792E-08	8.82526E-08	8.82084E-08
5.0E+14	8.81361E-08	8.81360E-08	8.81357E-08	8.81353E-08	8.81344E-08	8.81318E-08	8.81273E-08	8.81185E-08	8.80920E-08	8.80478E-08
1.0E+15	8.78695E-08	8.78694E-08	8.78691E-08	8.78687E-08	8.78678E-08	8.78651E-08	8.78607E-08	8.78519E-08	8.78254E-08	8.77814E-08
2.0E+15	8.73405E-08	8.73405E-08	8.73402E-08	8.73398E-08	8.73389E-08	8.73362E-08	8.73318E-08	8.73230E-08	8.72966E-08	8.72527E-08
5.0E+15	8.57877E-08	8.57876E-08	8.57874E-08	8.57869E-08	8.57861E-08	8.57834E-08	8.57791E-08	8.57703E-08	8.57442E-08	8.57006E-08
1.0E+16	8.33088E-08	8.33087E-08	8.33085E-08	8.33081E-08	8.33072E-08	8.33046E-08	8.33003E-08	8.32917E-08	8.32659E-08	8.32230E-08
2.0E+16	7.87324E-08	7.87323E-08	7.87321E-08	7.87317E-08	7.87308E-08	7.87283E-08	7.87241E-08	7.87157E-08	7.86906E-08	7.86486E-08
5.0E+16	6.75689E-08	6.75688E-08	6.75686E-08	6.75682E-08	6.75674E-08	6.75651E-08	6.75611E-08	6.75533E-08	6.75298E-08	6.74908E-08
1.0E+17	5.50741E-08	5.50741E-08	5.50739E-08	5.50735E-08	5.50728E-08	5.50706E-08	5.50670E-08	5.50598E-08	5.50381E-08	5.50021E-08
2.0E+17	4.22505E-08	4.22505E-08	4.22503E-08	4.22499E-08	4.22493E-08	4.22473E-08	4.22440E-08	4.22374E-08	4.22177E-08	4.21848E-08
5.0E+17	3.13414E-08	3.13413E-08	3.13412E-08	3.13409E-08	3.13403E-08	3.13385E-08	3.13355E-08	3.13295E-08	3.13115E-08	3.12816E-08
1.0E+18	2.70919E-08	2.70919E-08	2.70917E-08	2.70914E-08	2.70908E-08	2.70891E-08	2.70863E-08	2.70807E-08	2.70638E-08	2.70356E-08
2.0E+18	2.43791E-08	2.43790E-08	2.43789E-08	2.43786E-08	2.43781E-08	2.43765E-08	2.43738E-08	2.43685E-08	2.43525E-08	2.43259E-08
5.0E+18	2.17413E-08	2.17412E-08	2.17411E-08	2.17408E-08	2.17403E-08	2.17388E-08	2.17364E-08	2.17314E-08	2.17166E-08	2.16920E-08
1.0E+19	2.00502E-08	2.00501E-08	2.00500E-08	2.00497E-08	2.00493E-08	2.00479E-08	2.00456E-08	2.00410E-08	2.00271E-08	2.00041E-08
2.0E+19	1.79802E-08	1.79802E-08	1.79801E-08	1.79798E-08	1.79794E-08	1.79782E-08	1.79761E-08	1.79719E-08	1.79595E-08	1.79387E-08
5.0E+19	1.32896E-08	1.32896E-08	1.32895E-08	1.32893E-08	1.32890E-08	1.32881E-08	1.32865E-08	1.32835E-08	1.32742E-08	1.32588E-08
1.0E+20	8.05837E-09	8.05835E-09	8.05829E-09	8.05820E-09	8.05801E-09	8.05745E-09	8.05652E-09	8.05465E-09	8.04905E-09	8.03972E-09
2.0E+20	2.96406E-09	2.96405E-09	2.96403E-09	2.96400E-09	2.96393E-09	2.96372E-09	2.96338E-09	2.96269E-09	2.96063E-09	2.95720E-09
5.0E+20	1.47561E-10	1.47561E-10	1.47560E-10	1.47558E-10	1.47555E-10	1.47544E-10	1.47527E-10	1.47493E-10	1.47390E-10	1.47220E-10
1.0E+21	9.94256E-13	9.94254E-13	9.94247E-13	9.94235E-13	9.94212E-13	9.94143E-13	9.94028E-13	9.93797E-13	9.93106E-13	9.91954E-13
2.0E+21	4.51392E-17	4.51391E-17	4.51387E-17	4.51382E-17	4.51372E-17	4.51340E-17	4.51288E-17	4.51183E-17	4.50869E-17	4.50347E-17
5.0E+21	4.22395E-30	4.22394E-30	4.22391E-30	4.22386E-30	4.22377E-30	4.22347E-30	4.22298E-30	4.22200E-30	4.21907E-30	4.21417E-30
1.0E+22	8.14695E-52	8.14693E-52	8.14687E-52	8.14678E-52	8.14659E-52	8.14602E-52	8.14508E-52	8.14319E-52	8.13752E-52	8.12809E-52
2.0E+22	3.03073E-95	3.03072E-95	3.03070E-95	3.03066E-95	3.03059E-95	3.03038E-95	3.03003E-95	3.02933E-95	3.02722E-95	3.02371E-95
5.0E+22	1.56028-225	1.56027-225	1.56026-225	1.56025-225	1.56021-225	1.56010-225	1.55992-225	1.55956-225	1.55847-225	1.55667-225

Table B16. Total Photodissociation Rate Coefficients for the Process $CH_4 + h\nu \rightarrow CH_3 + H$ and $CH_4 + h\nu \rightarrow CH_2 + H_2$ for Wavelengths From 116 to 164 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19	2.0E+19	5.0E+19
1.0E+13	2.97405E-06	1.00972E-06	1.47022E-07	6.68945E-09	3.08733E-10	1.04272E-11	2.81811E-13	1.70092E-15	8.96768E-20	1.65681E-32
2.0E+13	2.97404E-06	1.00971E-06	1.47020E-07	6.68929E-09	3.08726E-10	1.04267E-11	2.81800E-13	1.70086E-15	8.96737E-20	1.65676E-32
5.0E+13	2.97402E-06	1.00970E-06	1.47014E-07	6.68880E-09	3.08705E-10	1.04251E-11	2.81767E-13	1.70068E-15	8.96644E-20	1.65659E-32
1.0E+14	2.97397E-06	1.00967E-06	1.47005E-07	6.68799E-09	3.08670E-10	1.04225E-11	2.81711E-13	1.70037E-15	8.96489E-20	1.65630E-32
2.0E+14	2.97388E-06	1.00962E-06	1.46986E-07	6.68636E-09	3.08599E-10	1.04172E-11	2.81598E-13	1.69976E-15	8.96178E-20	1.65573E-32
5.0E+14	2.97362E-06	1.00947E-06	1.46929E-07	6.68149E-09	3.08388E-10	1.04015E-11	2.81262E-13	1.69793E-15	8.95247E-20	1.65402E-32
1.0E+15	2.97318E-06	1.00922E-06	1.46836E-07	6.67341E-09	3.08038E-10	1.03752E-11	2.80703E-13	1.69489E-15	8.93698E-20	1.65116E-32
2.0E+15	2.97231E-06	1.00872E-06	1.46650E-07	6.65742E-09	3.07343E-10	1.03230E-11	2.79588E-13	1.68883E-15	8.90607E-20	1.64548E-32
5.0E+15	2.96975E-06	1.00726E-06	1.46106E-07	6.61059E-09	3.05298E-10	1.01682E-11	2.76272E-13	1.67076E-15	8.81398E-20	1.62854E-32
1.0E+16	2.96565E-06	1.00493E-06	1.45243E-07	6.53631E-09	3.02018E-10	9.91629E-12	2.70837E-13	1.64108E-15	8.66261E-20	1.60068E-32
2.0E+16	2.95803E-06	1.00064E-06	1.43663E-07	6.40065E-09	2.95910E-10	9.43464E-12	2.60304E-13	1.58332E-15	8.36763E-20	1.54640E-32
5.0E+16	2.93901E-06	9.90083E-07	1.39868E-07	6.07711E-09	2.80612E-10	8.14992E-12	2.31223E-13	1.42213E-15	7.54172E-20	1.39435E-32
1.0E+17	2.91601E-06	9.77741E-07	1.35633E-07	5.72204E-09	2.62314E-10	6.44865E-12	1.90115E-13	1.18956E-15	6.34261E-20	1.17343E-32
2.0E+17	2.88619E-06	9.62535E-07	1.30789E-07	5.32920E-09	2.40182E-10	4.18544E-12	1.29258E-13	8.33362E-16	4.48667E-20	8.31044E-33
5.0E+17	2.83373E-06	9.36986E-07	1.23131E-07	4.71518E-09	2.08904E-10	1.51164E-12	4.20697E-14	2.88918E-16	1.58959E-20	2.95208E-33
1.0E+18	2.77549E-06	9.09088E-07	1.14694E-07	3.99244E-09	1.79477E-10	6.26779E-13	6.94862E-15	5.03308E-17	2.82533E-21	5.25979E-34
2.0E+18	2.69502E-06	8.71894E-07	1.03686E-07	2.99423E-09	1.39490E-10	4.00527E-13	2.10012E-16	1.57316E-18	8.95419E-23	1.66975E-35
5.0E+18	2.55052E-06	8.11447E-07	8.81038E-08	1.56412E-09	7.64515E-11	2.35014E-13	1.48820E-20	5.01132E-23	2.86337E-27	5.34200E-40
1.0E+19	2.39877E-06	7.56935E-07	7.80292E-08	7.53982E-10	3.59062E-11	1.15361E-13	4.41494E-21	1.61778E-30	9.23199E-35	1.72236E-47
2.0E+19	2.16097E-06	6.79243E-07	6.80557E-08	2.87603E-10	1.07921E-11	3.40741E-14	1.37660E-21	6.86985E-34	9.59700E-50	1.79046E-62
5.0E+19	1.59844E-06	5.01530E-07	4.95741E-08	8.04976E-11	8.25926E-13	1.34214E-15	4.88948E-23	2.50008E-35	6.55496E-60	2.01134-107
1.0E+20	9.69103E-07	3.03930E-07	2.99520E-08	3.77365E-11	1.74347E-13	7.11941E-17	2.03812E-25	1.02089E-37	2.67860E-62	4.83842-136
2.0E+20	3.56417E-07	1.11747E-07	1.09914E-08	1.15635E-11	2.23765E-14	8.91530E-18	6.13352E-28	1.71209E-42	4.47371E-67	8.08099-141
5.0E+20	1.77430E-08	5.56222E-09	5.46641E-10	5.21449E-13	5.84820E-17	2.19873E-20	1.51205E-30	1.74615E-47	4.41294E-81	3.76484-155
1.0E+21	1.19551E-10	3.74776E-11	3.68306E-12	3.49569E-15	3.44764E-20	9.97961E-25	6.86469E-35	7.92750E-52	1.05722E-85	4.89272-179
2.0E+21	5.42760E-15	1.70148E-15	1.67210E-16	1.58699E-19	1.45465E-24	2.17916E-33	1.41492E-43	1.63398E-60	2.17910E-94	5.16854-196
5.0E+21	5.07895E-28	1.59218E-28	1.56469E-29	1.48504E-32	1.36120E-37	1.14364E-47	1.23897E-69	1.43080E-86	1.90813-120	4.52584-222
1.0E+22	9.79602E-50	3.07092E-50	3.01790E-51	2.86428E-54	2.62542E-59	2.20581E-69	1.30819E-99	5.32267-130	7.09839-164	1.68365-265
2.0E+22	3.64419E-93	1.14240E-93	1.12268E-94	1.06553E-97	9.76677-103	8.20576-113	4.86657-143	2.03734-193	9.82343-251	3.13457-153
5.0E+22	1.87610-223	5.86132-224	5.77979-225	5.48558-228	5.02813-233	4.22449-243	2.50541-273	1.55808E-50	9.97526E-69	2.97413-154

Table B16. Total Photodissociation Rate Coefficients for the Process $CH_4 + h\nu \rightarrow CH_3 + H$ and $CH_4 + h\nu \rightarrow CH_2 + H_2$ for Wavelengths From 116 to 164 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16
1.0E+13	9.08194E-06	9.07579E-06	9.06555E-06	9.04511E-06	8.98408E-06	8.88328E-06	8.68510E-06	8.11710E-06	7.25294E-06	5.79465E-06
2.0E+13	9.08192E-06	9.07577E-06	9.06554E-06	9.04510E-06	8.98406E-06	8.88326E-06	8.68509E-06	8.11708E-06	7.25293E-06	5.79464E-06
5.0E+13	9.08187E-06	9.07573E-06	9.06549E-06	9.04505E-06	8.98401E-06	8.88321E-06	8.68504E-06	8.11704E-06	7.25289E-06	5.79460E-06
1.0E+14	9.08179E-06	9.07564E-06	9.06541E-06	9.04497E-06	8.98393E-06	8.88313E-06	8.68496E-06	8.11696E-06	7.25281E-06	5.79454E-06
2.0E+14	9.08163E-06	9.07548E-06	9.06524E-06	9.04480E-06	8.98377E-06	8.88297E-06	8.68480E-06	8.11680E-06	7.25267E-06	5.79441E-06
5.0E+14	9.08113E-06	9.07499E-06	9.06475E-06	9.04431E-06	8.98328E-06	8.88248E-06	8.68432E-06	8.11634E-06	7.25224E-06	5.79403E-06
1.0E+15	9.08031E-06	9.07417E-06	9.06393E-06	9.04349E-06	8.98246E-06	8.88167E-06	8.68352E-06	8.11557E-06	7.25152E-06	5.79340E-06
2.0E+15	9.07869E-06	9.07254E-06	9.06231E-06	9.04187E-06	8.98085E-06	8.88007E-06	8.68193E-06	8.11405E-06	7.25009E-06	5.79214E-06
5.0E+15	9.07390E-06	9.06775E-06	9.05752E-06	9.03709E-06	8.97609E-06	8.87534E-06	8.67727E-06	8.10957E-06	7.24589E-06	5.78844E-06
1.0E+16	9.06620E-06	9.06006E-06	9.04983E-06	9.02941E-06	8.96844E-06	8.86774E-06	8.66977E-06	8.10236E-06	7.23914E-06	5.78251E-06
2.0E+16	9.05178E-06	9.04565E-06	9.03543E-06	9.01503E-06	8.95411E-06	8.85351E-06	8.65573E-06	8.08888E-06	7.22652E-06	5.77144E-06
5.0E+16	9.01504E-06	9.00892E-06	8.99873E-06	8.97838E-06	8.91762E-06	8.81727E-06	8.61999E-06	8.05459E-06	7.19451E-06	5.74346E-06
1.0E+17	8.96886E-06	8.96276E-06	8.95260E-06	8.93232E-06	8.87176E-06	8.77175E-06	8.57514E-06	8.01166E-06	7.15458E-06	5.70883E-06
2.0E+17	8.90571E-06	8.89964E-06	8.88953E-06	8.86935E-06	8.80909E-06	8.70957E-06	8.51393E-06	7.95327E-06	7.10056E-06	5.66249E-06
5.0E+17	8.78855E-06	8.78254E-06	8.77253E-06	8.75255E-06	8.69287E-06	8.59433E-06	8.40061E-06	7.84552E-06	7.00142E-06	5.57836E-06
1.0E+18	8.65430E-06	8.64836E-06	8.63847E-06	8.61872E-06	8.55976E-06	8.46238E-06	8.27097E-06	7.72252E-06	6.88866E-06	5.48332E-06
2.0E+18	8.45984E-06	8.45401E-06	8.44430E-06	8.42492E-06	8.36703E-06	8.27144E-06	8.08355E-06	7.54522E-06	6.72692E-06	5.34834E-06
5.0E+18	8.07597E-06	8.07037E-06	8.06105E-06	8.04245E-06	7.98690E-06	7.89516E-06	7.71484E-06	7.19828E-06	6.41325E-06	5.09131E-06
1.0E+19	7.62587E-06	7.62057E-06	7.61175E-06	7.59414E-06	7.54156E-06	7.45473E-06	7.28406E-06	6.79516E-06	6.05224E-06	4.80145E-06
2.0E+19	6.88190E-06	6.87711E-06	6.86914E-06	6.85324E-06	6.80573E-06	6.72730E-06	6.57313E-06	6.13150E-06	5.46043E-06	4.33069E-06
5.0E+19	5.09443E-06	5.09088E-06	5.08498E-06	5.07320E-06	5.03802E-06	4.97993E-06	4.86576E-06	4.53870E-06	4.04172E-06	3.20510E-06
1.0E+20	3.08932E-06	3.08717E-06	3.08359E-06	3.07644E-06	3.05511E-06	3.01988E-06	2.95063E-06	2.75228E-06	2.45087E-06	1.94347E-06
2.0E+20	1.13635E-06	1.13556E-06	1.13424E-06	1.13162E-06	1.12377E-06	1.11081E-06	1.08533E-06	1.01237E-06	9.01491E-07	7.14841E-07
5.0E+20	5.65726E-08	5.65333E-08	5.64677E-08	5.63369E-08	5.59461E-08	5.53009E-08	5.40327E-08	5.03999E-08	4.48799E-08	3.55873E-08
1.0E+21	3.81183E-10	3.80917E-10	3.80476E-10	3.79594E-10	3.76961E-10	3.72614E-10	3.64069E-10	3.39591E-10	3.02397E-10	2.39785E-10
2.0E+21	1.73057E-14	1.72936E-14	1.72736E-14	1.72335E-14	1.71140E-14	1.69166E-14	1.65287E-14	1.54174E-14	1.37288E-14	1.08862E-14
5.0E+21	1.61940E-27	1.61827E-27	1.61640E-27	1.61265E-27	1.60146E-27	1.58300E-27	1.54669E-27	1.44270E-27	1.28469E-27	1.01869E-27
1.0E+22	3.12341E-49	3.12124E-49	3.11762E-49	3.11040E-49	3.08882E-49	3.05320E-49	2.98318E-49	2.78261E-49	2.47785E-49	1.96480E-49
2.0E+22	1.16193E-92	1.16113E-92	1.15978E-92	1.15709E-92	1.14907E-92	1.13581E-92	1.10977E-92	1.03515E-92	9.21779E-93	7.30921E-93
5.0E+22	5.98187-223	5.97771-223	5.97078-223	5.95694-223	5.91562-223	5.84740-223	5.71330-223	5.32918-223	4.74550-223	3.76293-223

Table B16. Total Photodissociation Rate Coefficients for the Process $CH_4 + h\nu \rightarrow CH_3 + H$ and $CH_4 + h\nu \rightarrow CH_2 + H_2$ for Wavelengths From 116 to 164 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+10	2.0E+10	5.0E+10	1.0E+11	2.0E+11	5.0E+11	1.0E+12	2.0E+12	5.0E+12	1.0E+13
1.0E+13	9.08604E-06	9.08604E-06	9.08603E-06	9.08602E-06	9.08600E-06	9.08594E-06	9.08583E-06	9.08563E-06	9.08501E-06	9.08399E-06
2.0E+13	9.08602E-06	9.08602E-06	9.08601E-06	9.08600E-06	9.08598E-06	9.08592E-06	9.08582E-06	9.08561E-06	9.08500E-06	9.08397E-06
5.0E+13	9.08597E-06	9.08597E-06	9.08596E-06	9.08595E-06	9.08593E-06	9.08587E-06	9.08577E-06	9.08556E-06	9.08495E-06	9.08392E-06
1.0E+14	9.08589E-06	9.08589E-06	9.08588E-06	9.08587E-06	9.08585E-06	9.08579E-06	9.08569E-06	9.08548E-06	9.08487E-06	9.08384E-06
2.0E+14	9.08572E-06	9.08572E-06	9.08572E-06	9.08571E-06	9.08569E-06	9.08562E-06	9.08552E-06	9.08532E-06	9.08470E-06	9.08368E-06
5.0E+14	9.08523E-06	9.08523E-06	9.08522E-06	9.08521E-06	9.08519E-06	9.08513E-06	9.08503E-06	9.08482E-06	9.08421E-06	9.08318E-06
1.0E+15	9.08441E-06	9.08441E-06	9.08440E-06	9.08439E-06	9.08437E-06	9.08431E-06	9.08421E-06	9.08400E-06	9.08339E-06	9.08236E-06
2.0E+15	9.08279E-06	9.08278E-06	9.08278E-06	9.08277E-06	9.08275E-06	9.08269E-06	9.08258E-06	9.08238E-06	9.08176E-06	9.08074E-06
5.0E+15	9.07799E-06	9.07799E-06	9.07799E-06	9.07798E-06	9.07796E-06	9.07789E-06	9.07779E-06	9.07759E-06	9.07697E-06	9.07595E-06
1.0E+16	9.07029E-06	9.07029E-06	9.07028E-06	9.07027E-06	9.07025E-06	9.07019E-06	9.07009E-06	9.06988E-06	9.06927E-06	9.06825E-06
2.0E+16	9.05587E-06	9.05587E-06	9.05587E-06	9.05586E-06	9.05584E-06	9.05577E-06	9.05567E-06	9.05547E-06	9.05485E-06	9.05383E-06
5.0E+16	9.01912E-06	9.01912E-06	9.01912E-06	9.01911E-06	9.01909E-06	9.01902E-06	9.01892E-06	9.01872E-06	9.01811E-06	9.01708E-06
1.0E+17	8.97293E-06	8.97292E-06	8.97292E-06	8.97291E-06	8.97289E-06	8.97283E-06	8.97273E-06	8.97252E-06	8.97191E-06	8.97089E-06
2.0E+17	8.90976E-06	8.90975E-06	8.90975E-06	8.90974E-06	8.90972E-06	8.90966E-06	8.90956E-06	8.90935E-06	8.90875E-06	8.90773E-06
5.0E+17	8.79256E-06	8.79255E-06	8.79255E-06	8.79254E-06	8.79252E-06	8.79246E-06	8.79236E-06	8.79216E-06	8.79156E-06	8.79055E-06
1.0E+18	8.65826E-06	8.65826E-06	8.65825E-06	8.65824E-06	8.65822E-06	8.65816E-06	8.65806E-06	8.65787E-06	8.65727E-06	8.65628E-06
2.0E+18	8.46373E-06	8.46373E-06	8.46372E-06	8.46371E-06	8.46369E-06	8.46363E-06	8.46353E-06	8.46334E-06	8.46276E-06	8.46178E-06
5.0E+18	8.07970E-06	8.07970E-06	8.07969E-06	8.07968E-06	8.07966E-06	8.07961E-06	8.07952E-06	8.07933E-06	8.07877E-06	8.07784E-06
1.0E+19	7.62940E-06	7.62940E-06	7.62939E-06	7.62938E-06	7.62937E-06	7.62931E-06	7.62922E-06	7.62905E-06	7.62852E-06	7.62763E-06
2.0E+19	6.88509E-06	6.88508E-06	6.88508E-06	6.88507E-06	6.88505E-06	6.88501E-06	6.88493E-06	6.88477E-06	6.88429E-06	6.88349E-06
5.0E+19	5.09679E-06	5.09679E-06	5.09678E-06	5.09678E-06	5.09677E-06	5.09673E-06	5.09667E-06	5.09655E-06	5.09620E-06	5.09561E-06
1.0E+20	3.09075E-06	3.09075E-06	3.09075E-06	3.09074E-06	3.09074E-06	3.09072E-06	3.09068E-06	3.09061E-06	3.09039E-06	3.09003E-06
2.0E+20	1.13688E-06	1.13688E-06	1.13688E-06	1.13688E-06	1.13687E-06	1.13686E-06	1.13685E-06	1.13683E-06	1.13675E-06	1.13661E-06
5.0E+20	5.65989E-08	5.65989E-08	5.65988E-08	5.65988E-08	5.65986E-08	5.65982E-08	5.65976E-08	5.65963E-08	5.65923E-08	5.65858E-08
1.0E+21	3.81359E-10	3.81359E-10	3.81359E-10	3.81359E-10	3.81358E-10	3.81355E-10	3.81351E-10	3.81342E-10	3.81315E-10	3.81271E-10
2.0E+21	1.73137E-14	1.73137E-14	1.73137E-14	1.73137E-14	1.73136E-14	1.73135E-14	1.73133E-14	1.73129E-14	1.73117E-14	1.73097E-14
5.0E+21	1.62015E-27	1.62015E-27	1.62015E-27	1.62015E-27	1.62014E-27	1.62013E-27	1.62011E-27	1.62007E-27	1.61996E-27	1.61977E-27
1.0E+22	3.12486E-49	3.12486E-49	3.12486E-49	3.12486E-49	3.12485E-49	3.12483E-49	3.12479E-49	3.12472E-49	3.12450E-49	3.12414E-49
2.0E+22	1.16247E-92	1.16247E-92	1.16247E-92	1.16247E-92	1.16247E-92	1.16246E-92	1.16245E-92	1.16242E-92	1.16234E-92	1.16220E-92
5.0E+22	5.98464-223	5.98464-223	5.98464-223	5.98463-223	5.98462-223	5.98457-223	5.98451-223	5.98437-223	5.98395-223	5.98326-223

Table B15. Total Photodissociation Rate Coefficients for the Process $HNO_3 + h\nu \rightarrow OH + NO_2$ for Wavelengths From 192 to 325 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+18	1.0E+19	2.0E+19
1.0E+17	1.13617E-05	2.63273E-06	5.63548E-07
2.0E+17	1.13616E-05	2.63273E-06	5.63547E-07
5.0E+17	1.13616E-05	2.63272E-06	5.63547E-07
1.0E+18	1.13615E-05	2.63270E-06	5.63546E-07
2.0E+18	1.13613E-05	2.63266E-06	5.63545E-07
5.0E+18	1.13606E-05	2.63255E-06	5.63541E-07
1.0E+19	1.13596E-05	2.63236E-06	5.63535E-07
2.0E+19	1.13575E-05	2.63199E-06	5.63523E-07
5.0E+19	1.13512E-05	2.63089E-06	5.63486E-07
1.0E+20	1.13409E-05	2.62909E-06	5.63426E-07
2.0E+20	1.13210E-05	2.62559E-06	5.63309E-07
5.0E+20	1.13110E-05	2.62442E-06	5.63288E-07
1.0E+21	1.12486E-05	2.61386E-06	5.62947E-07
2.0E+21	1.11479E-05	2.59721E-06	5.62421E-07
5.0E+21	1.09320E-05	2.56332E-06	5.61404E-07
1.0E+22	1.04726E-05	2.48729E-06	5.58976E-07

Table B20. Total Photodissociation Rate Coefficients for the Process $HO_2 + h\nu \rightarrow O_2 + H$ for Wavelengths From 180 to 274 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY							
	5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20	5.0E+20	1.0E+21
1.0E+17	2.07907E-05	2.61694E-06	6.76290E-08	2.73147E-12	1.93021E-19	1.13611E-33	2.83493E-76	3.46592-147
2.0E+17	2.07901E-05	2.61691E-06	6.76288E-08	2.73146E-12	1.93020E-19	1.13610E-33	2.83492E-76	3.46592-147
5.0E+17	2.07884E-05	2.61683E-06	6.76281E-08	2.73145E-12	1.93019E-19	1.13610E-33	2.83491E-76	3.46590-147
1.0E+18	2.07857E-05	2.61671E-06	6.76269E-08	2.73142E-12	1.93017E-19	1.13609E-33	2.83489E-76	3.46587-147
2.0E+18	2.07810E-05	2.61648E-06	6.76246E-08	2.73136E-12	1.93014E-19	1.13607E-33	2.83484E-76	3.46582-147
5.0E+18	2.07695E-05	2.61584E-06	6.76178E-08	2.73119E-12	1.93003E-19	1.13601E-33	2.83471E-76	3.46565-147
1.0E+19	2.07543E-05	2.61491E-06	6.76067E-08	2.73091E-12	1.92986E-19	1.13592E-33	2.83448E-76	3.46537-147
2.0E+19	2.07301E-05	2.61326E-06	6.75849E-08	2.73035E-12	1.92951E-19	1.13573E-33	2.83403E-76	3.46482-147
5.0E+19	2.06766E-05	2.60908E-06	6.75224E-08	2.72868E-12	1.92847E-19	1.13517E-33	2.83268E-76	3.46316-147
1.0E+20	2.06103E-05	2.60322E-06	6.74242E-08	2.72592E-12	1.92674E-19	1.13425E-33	2.83043E-76	3.46040-147
2.0E+20	2.05089E-05	2.59329E-06	6.72410E-08	2.72054E-12	1.92334E-19	1.13240E-33	2.82596E-76	3.45491-147
5.0E+20	2.04746E-05	2.59002E-06	6.71908E-08	2.71987E-12	1.92320E-19	1.13240E-33	2.82596E-76	3.45491-147
1.0E+21	2.02330E-05	2.56402E-06	6.66700E-08	2.70405E-12	1.91321E-19	1.12696E-33	2.81276E-76	3.43872-147
2.0E+21	1.99118E-05	2.52725E-06	6.58848E-08	2.67907E-12	1.89725E-19	1.11818E-33	2.79132E-76	3.41247-147
5.0E+21	1.92876E-05	2.45557E-06	6.43467E-08	2.63067E-12	1.86663E-19	1.10128E-33	2.74998E-76	3.36199-147
1.0E+22	1.81656E-05	2.31546E-06	6.09623E-08	2.50741E-12	1.78360E-19	1.05394E-33	2.63347E-76	3.21992-147
2.0E+22	1.64708E-05	2.10592E-06	5.58782E-08	2.32054E-12	1.65729E-19	9.81483E-34	2.45436E-76	3.00131-147
5.0E+22	1.29553E-05	1.69200E-06	4.63024E-08	1.98438E-12	1.43372E-19	8.53578E-34	2.13714E-76	2.61328-147
1.0E+23	8.11202E-06	1.06391E-06	2.96259E-08	1.29948E-12	9.48660E-20	5.67955E-34	1.42349E-76	1.73821-147
2.0E+23	3.52091E-06	4.80146E-07	1.41310E-08	6.52939E-13	4.85590E-20	2.93040E-34	7.34125E-77	8.92785-148
5.0E+23	5.60412E-07	9.47195E-08	3.31736E-09	1.71564E-13	1.31614E-20	8.03035E-35	2.00348E-77	2.41106-148
1.0E+24	1.09755E-08	1.96109E-09	7.17647E-11	3.82061E-15	2.95631E-22	1.80327E-36	4.40430E-79	5.10966-150
2.0E+24	8.94604E-10	1.68185E-10	6.17187E-12	3.23815E-16	2.47282E-23	1.48928E-37	3.56769E-80	4.02630-151
5.0E+24	8.94366E-10	1.68179E-10	6.17183E-12	3.23815E-16	2.47282E-23	1.48928E-37	3.56769E-80	4.02630-151
1.0E+25	8.94366E-10	1.68179E-10	6.17183E-12	3.23815E-16	2.47282E-23	1.48928E-37	3.56769E-80	4.02630-151
2.0E+25	8.94366E-10	1.68179E-10	6.17183E-12	3.23815E-16	2.47282E-23	1.48928E-37	3.56769E-80	4.02630-151

Table B21. EUV Solar Fluxes and Cross Sections

WAVELENGTH A	PHOTON FLUX X10^{9} PH/CM /SEC	O2 X10^{-18}	N2 X10^{-18}	O X10^{-18}	O2 X10^{-18}	N2 X10^{-18}	O X10^{-18}	H X10^{-18}	HE X10^{-18}
1215.7	251.4000	.0100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1025.7	2.6670	1.5800	.0005	0.0000	.9800	0.0000	0.0000	0.0000	0.0000
991.0	.5994	1.6000	1.5000	0.0000	1.1000	0.0000	0.0000	0.0000	0.0000
977.0	4.4070	4.0000	.7000	0.0000	2.5000	0.0000	0.0000	0.0000	0.0000
972.5	.6066	32.0000	360.0000	0.0000	25.0000	0.0000	0.0000	0.0000	0.0000
949.7	.3044	6.3000	5.2000	0.0000	4.0000	0.0000	0.0000	0.0000	0.0000
944.5	.1340	3.2000	1.0000	0.0000	2.6000	0.0000	0.0000	0.0000	0.0000
937.8	.1635	5.0000	10.0000	0.0000	3.0000	0.0000	0.0000	0.0000	0.0000
933.4	.1433	18.0000	.2000	0.0000	8.0000	0.0000	0.0000	0.0000	0.0000
930.7	.2631	26.0000	4.8000	0.0000	17.0000	0.0000	0.0000	0.0000	0.0000
926.2	.1129	6.7000	2.0000	0.0000	6.7000	0.0000	0.0000	0.0000	0.0000
	.0284	7.4000	100.0000	0.0000	3.3000	0.0000	0.0000	0.0000	0.0000
	.1134	7.4000	50.0000	0.0000	3.3000	0.0000	0.0000	0.0000	0.0000
911-1027	.3970	7.4000	10.0000	0.0000	3.3000	0.0000	0.0000	0.0000	0.0000
	.5388	7.4000	2.0000	0.0000	3.3000	0.0000	0.0000	0.0000	0.0000
	.3403	7.4000	.2000	0.0000	3.3000	0.0000	0.0000	0.0000	0.0000
890-911	1.1064	9.3000	10.0000	3.0000	4.5000	0.0000	3.0000	6.1000	0.0000
	2.5816	9.3000	2.0000	3.0000	4.5000	0.0000	3.0000	6.1000	0.0000
904	.3625	11.0000	6.3000	3.0000	6.3000	0.0000	3.0000	6.1200	0.0000
860-890	1.1852	7.0000	10.0000	2.9000	4.0000	0.0000	2.9000	5.8000	0.0000
	1.7778	7.0000	2.0000	2.9000	4.0000	0.0000	2.9000	5.8000	0.0000
830- 60	.5436	9.0000	10.0000	2.8000	4.0000	0.0000	2.8000	5.2000	0.0000
	.8154	9.0000	2.0000	2.8000	4.0000	0.0000	2.8000	5.2000	0.0000
835.3	.0950	10.0000	20.0000	2.6000	3.7000	0.0000	2.6000	5.0000	0.0000
835.1	.0950	10.0000	41.0000	2.6000	3.7000	0.0000	2.6000	5.0000	0.0000
834.5	.0950	1..0000	7.5000	2.6000	4.0000	0.0000	2.6000	5.0000	0.0000
833.7	.0950	13.0000	6.0000	2.6000	5.1000	0.0000	2.6000	5.0000	0.0000
833.3	.0950	15.0000	2.3000	2.6000	6.0000	0.0000	2.6000	5.0000	0.0000
832.9	.0950	26.0000	7.0000	2.6000	10.0000	0.0000	2.6000	5.0000	0.0000
832.8	.0950	26.0000	2.1000	2.6000	10.0000	0.0000	2.6000	5.0000	0.0000
	.0654	19.0000	50.0000	2.9000	7.0000	0.0000	2.9000	4.8000	0.0000
800-830	.1962	19.0000	10.0000	2.9000	7.0000	0.0000	2.9000	4.8000	0.0000
	.3924	19.0000	2.0000	2.9000	7.0000	0.0000	2.9000	4.8000	0.0000
	.0027	26.0000	100.0000	3.0000	10.0000	65.0000	3.0000	4.3000	0.0000
770-800	.0539	26.0000	50.0000	3.0000	10.0000	33.0000	3.0000	4.3000	0.0000
	.2129	26.0000	25.0000	3.0000	10.0000	16.0000	3.0000	4.3000	0.0000
790.1	.3814	28.0000	25.0000	2.9000	10.0000	11.0000	2.9000	4.4000	0.0000
787.7	.2107	24.0000	10.0000	2.9000	13.0000	8.0000	2.9000	4.3000	0.0000
786.5	.1103	23.0000	44.0000	2.9000	7.0000	33.0000	2.9000	4.3000	0.0000
780.3	.2289	28.0000	30.0000	2.0000	11.0000	17.0000	2.9000	4.3000	0.0000
770.4	.2869	18.0000	12.0000	7.0000	11.0000	7.8000	7.0000	4.1000	0.0000
740-770	.0128	19.0000	50.0000	3.3000	11.0000	35.0000	3.3000	3.9000	0.0000
	.1698	19.0000	24.0000	3.3000	11.0000	17.0000	3.3000	3.9000	0.0000
765.1	.1659	23.0000	67.0000	3.0000	12.0000	51.0000	3.0000	4.0000	0.0000
760.4	.0934	20.0000	40.0000	2.9000	10.0000	22.0000	2.9000	3.9000	0.0000
710-740	.0895	30.0000	23.0000	5.5000	22.0000	21.0000	5.5000	3.5000	0.0000

Table B21. EUV Solar Fluxes and Cross Sections (Contd)

WAVELENGTH A	PHOTON FLUX $X10^9$ PH/CM /SEC	O2 $X10^{-18}$	N2 $X10^{-18}$	O $X10^{-18}$	O2 $X10^{-18}$	N2 $X10^{-18}$	O $X10^{-18}$	H $X10^{-18}$	HE $X10^{-18}$
680-710	.1290	24.0000	23.0000	6.5000	20.0000	21.0000	6.5000	3.1000	0.0000
703	.0673	26.0000	23.0000	6.5000	23.0000	21.0000	6.5000	3.1000	0.0000
630-680	.0004	22.0000	50.0000	6.0000	19.0000	50.0000	6.0000	3.4000	0.0000
	.0627	22.0000	24.0000	6.0000	19.0000	24.0000	6.0000	3.4000	0.0000
629.7	1.5203	30.0000	23.0000	9.0000	29.0000	23.0000	9.0000	2.4000	0.0000
625.3	.2103	25.0000	24.0000	9.0000	24.0000	23.0000	9.0000	2.4000	0.0000
609.8	.5302	27.0000	24.0000	9.0000	25.0000	24.0000	9.0000	2.1000	0.0000
599.6	.1600	28.0000	23.0000	9.0000	27.0000	22.0000	9.0000	2.0000	0.0000
584.3	1.2700	23.0000	23.0000	9.5000	23.0000	23.0000	9.5000	1.9000	0.0000
554	.7200	26.0000	25.0000	9.5000	25.0000	24.0000	9.5000	1.6000	0.0000
521.0	.0600	21.0000	24.0000	9.3000	21.0000	23.0000	9.3000	1.3000	0.0000
507	.1600	23.0000	23.0000	9.3000	22.0000	23.0000	9.3000	1.2000	0.0000
425-504	.4429	22.0000	23.0000	9.5000	22.0000	23.0000	9.5000	1.0000	7.0000
499.3	.1139	22.0000	23.0000	9.5000	22.0000	23.0000	9.5000	1.2000	8.2000
465.2	.2724	21.0000	23.0000	10.0000	21.0000	23.0000	10.0000	1.0000	6.6000
417	.0782	20.0000	21.0000	10.5000	20.0000	21.0000	10.5000	.7400	5.6000
370-460	.1715	20.0000	20.0000	10.0000	20.0000	20.0000	10.0000	.7600	5.6000
368.1	.6500	18.0000	17.0000	9.5000	18.0000	17.0000	9.5000	.5400	4.6000
365	.1500	18.0000	16.0000	9.5000	18.0000	16.0000	9.5000	.5400	4.6000
360.7	.3200	17.0000	16.0000	9.5000	17.0000	16.0000	9.5000	.5000	4.6000
335.4	.1600	17.0000	14.0000	9.0000	17.0000	14.0000	9.0000	.4000	4.1000
303.8	7.7000	17.0000	12.0000	8.5000	17.0000	12.0000	8.5000	.3000	3.5000
284.1	.2100	15.0000	11.0000	8.5000	15.0000	11.0000	8.5000	.2500	2.7000
270-370	1.1770	16.0000	13.0000	8.5000	18.0000	13.0000	8.5000	.3700	3.6000
230-270	2.3960	13.0000	10.0000	7.5000	22.0000	13.0000	15.0000	.1900	2.1000
205-230	.6035	10.0000	7.0000	6.5000	20.0000	14.0000	13.0000	.1100	1.5000
176-205	2.0881	6.4000	5.6000	4.0000	12.8000	11.0000	8.0000	.0740	1.0000
153-176	1.2133	5.2000	4.4000	3.0000	10.4000	9.0000	6.0000	.0470	.7300
100-153	.2017	3.0000	2.7000	1.7000	7.5000	5.4000	5.1000	.0250	.3800
90-100	.0942	2.0000	1.2000	1.0000	6.0000	3.6000	3.0000	.0085	.1800
80-90	.1070	1.5000	.8900	.7500	4.5000	2.7000	2.3000	.0063	.1500
76.0	.0167	1.1000	.6700	.5500	4.4000	2.7000	2.3000	.0042	.1000
70-80	.0648	1.1000	.6500	.5500	4.4000	2.6000	2.3000	.0045	.1100
60-70	.0742	.8000	.4500	.3900	4.0000	1.8000	2.0000	.0025	.0900
50-60	.0643	.5100	.3000	.2500	3.1000	1.8000	1.5000	.0012	.0200
40-50	.0284	.3100	.1800	.1600	2.2000	1.4000	1.1000	0.0000	.0190
10-40	.0040	.1500	.0900	.0800	1.5000	.9000	.8000	0.0000	.0050
9	0.0000	.1000	.0650	.0500	3.9000	2.5000	2.0000	0.0000	0.0000
7	0.0000	.0520	.0300	.0260	2.6000	1.5000	1.3000	0.0000	0.0000
5	0.0000	.0200	.0120	.0100	1.4000	.8400	.7100	0.0000	0.0000
3	0.0000	.0046	.0028	.0023	.5400	.3300	.2700	0.0000	0.0000
1	0.0000	.0002	.0001	.0001	.0600	.0350	.2300	0.0000	0.0000

Table B22. Electron Impact Ionization Cross Sections

PROCESS	I	$c_o f_o$	Ω	ν	γ	P
$e + N_2 \rightarrow N + N^+ + 2e$	25.0	0.380	0.96	2.0	1.0	1.2
$e + O_2 \rightarrow O + O^+(^4S) + 2e$	18.0	0.400	0.93	3.0	1.0	1.1
$e + O_2 \rightarrow O + O^+(^2D) + 2e$	22.0	0.250	0.93	3.0	1.0	1.1
$e + O \rightarrow O^+(^4S) + 2e$	14.0	0.290	0.85	1.0	0.3	1.2
$e + O \rightarrow O^+(^2D) + 2e$	17.0	0.360	0.85	1.0	0.3	1.2
$e + N_2 \rightarrow N_2^+ + 2e$	15.0	0.370	0.80	3.0	1.0	1.2
$e + O_2 \rightarrow O_2^+ + 2e$	12.0	0.058	0.80	2.0	1.0	1.1

Table B23. Rate Coefficients for Energetic Electron Impact Reactions

1. $N_2 + e \rightarrow N + N^+ + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	3.54E-12	7.83E-13	3.37E-15	0
130	7.46E-10	5.79E-10	3.07E-10	0
170	2.60E-09	2.25E-09	1.45E-09	0
210	3.92E-09	3.69E-09	3.03E-09	0
250	4.73E-09	4.61E-09	4.22E-09	0
300	5.27E-09	5.21E-09	5.04E-09	0
400	2.63E-09	2.60E-09	2.52E-09	0

2. $O_2 + e \rightarrow O + O^+(^4S) + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	4.38E-12	9.68E-13	4.16E-15	0
130	1.00E-09	7.49E-10	3.87E-10	0
170	4.60E-09	3.84E-09	2.20E-09	0
210	7.31E-09	6.81E-09	5.35E-09	0
250	8.86E-09	8.59E-09	7.73E-09	0
300	9.76E-09	9.61E-09	9.25E-09	0
400	4.38E-09	4.81E-09	4.62E-09	0

Table B23. Rate Coefficients for Energetic Electron Impact Reactions (Contd)

3. $O_2 + e \rightarrow O + O^+(^2D) + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	2.06E-12	4.56E-13	1.97E-15	0
130	4.11E-10	3.22E-10	1.74E-10	0
170	1.35E-09	1.17E-09	7.74E-10	0
210	2.01E-09	1.90E-09	1.57E-09	0
250	2.42E-09	2.36E-09	2.17E-09	0
300	2.70E-09	2.67E-09	2.59E-09	0
400	1.35E-09	1.33E-09	1.29E-09	0

4. $O + e \rightarrow O^+(^4S) + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	5.90E-12	1.29E-12	5.53E-15	0
130	2.08E-09	1.29E-09	5.73E-10	0
170	2.37E-09	1.79E-08	7.26E-09	0
210	4.26E-08	3.85E-08	2.70E-08	0
250	5.09E-08	4.88E-08	4.22E-08	0
300	5.22E-08	5.08E-08	4.82E-08	0
400	2.61E-08	2.54E-08	2.41E-08	0

5. $O + e \rightarrow O^+(^2D) + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	4.23E-12	9.30E-13	3.98E-15	0
130	1.28E-09	8.51E-10	3.40E-10	0
170	1.07E-08	8.35E-09	3.80E-09	0
210	1.84E-08	1.68E-08	1.22E-08	0
250	2.22E-08	2.13E-08	1.86E-08	0
300	2.36E-08	2.31E-08	2.20E-08	0
400	1.18E-08	1.15E-08	1.10E-08	0

Table B23. Rate Coefficients for Energetic Electron Impact Reactions (Contd)

6. $N_2 + e \rightarrow N_2^+ + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	6.12E-12	1.34E-12	5.80E-15	0
130	1.55E-09	1.11E-09	5.52E-10	0
170	9.31E-09	7.51E-09	3.86E-09	0
210	1.54E-08	1.42E-08	1.07E-08	0
250	1.87E-08	1.80E-08	1.60E-08	0
300	2.02E-08	1.98E-08	1.90E-08	0
400	1.01E-08	9.91E-09	9.49E-09	0

7. $O_2 + e \rightarrow O_2^+ + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	1.81E-12	3.97E-13	1.70E-15	0
130	6.32E-10	3.94E-10	1.76E-10	0
170	7.14E-09	5.40E-09	2.19E-09	0
210	1.29E-08	1.17E-08	8.18E-09	0
250	1.55E-08	1.48E-08	1.28E-08	0
300	1.60E-08	1.53E-08	1.45E-08	0
400	7.90E-09	7.67E-09	7.27E-09	0

8. $N_2 + e \rightarrow N + N(^2D) + e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	1.64E-11	3.59E-12	1.54E-14	0
130	6.27E-09	3.71E-09	1.60E-09	0
170	9.42E-08	6.93E-08	2.53E-08	0
210	1.82E-07	1.63E-07	1.11E-07	0
250	2.22E-07	2.12E-07	1.81E-07	0
300	2.11E-07	2.03E-07	1.91E-07	0
400	1.05E-07	1.01E-07	9.55E-08	0

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Appendix C

The Computer Code

The computer code used to develop the simulated atmosphere described in this report is presented in detail in this Appendix.

To conserve computer memory, the code was written in OVERLAYs. Once all the initialization is completed at the beginning of a run, there is no need to retain in memory all the code that accomplished this.

The code is written in FORTRAN IV for a CDC 6600 mainframe computer. It also utilizes a large block of extended core storage for saving the concentration arrays, the average velocity arrays, and the reaction rate coefficient arrays at the beginning of each time step. If extended core is not available, these sections of the code have to be rewritten to use whatever disk or, as a last resort, tape storage is available. Using disk or tape storage significantly increases the residence time of the code on the computer.

C1. THE MAIN OVERLAY (0,0)

The main overlay is relatively short. It defines all the blank COMMON variables shared by all the overlays. It also defines the parameters that describe the simulation to be generated as well as the error criteria. It calls OVERLAYs (1,0) and (2,0).

C1.1 Blank COMMON

There are 692 height steps between the lower and the upper boundaries in this model. The 424 height steps between the lower boundary and 120 km represent the region over which the negative ions and the cluster ions are calculated.

N is one of the dependent variable arrays. It contains the altitude distribution of the concentrations of the 26 species in the transport mode plus the arrays for $O(^1D)$, N_2^+, $O^+(^2D)$, and the electrons.

CONC is also a dependent variable array. It contains the height distributions for those species considered over the smaller altitude region.

U is another dependent variable array. Here are stored the values at each altitude of the average velocities of those species in the transport mode.

NZERO and UZERO are working arrays that contain the values of N and U for the particular species whose set of equations is being solved at any given time.

FORM and REMV contain the altitude arrays of the rate of chemical formation [P in Eq. (1)] and chemical removal [L in Eq. (1)] for the species whose equations are being solved.

E and F contain the altitude arrays of E and F in Eq. (28) for the species under consideration.

Z is the altitude array in kilometers.

DEDY is the array containing the fixed vertical turbulent diffusion coefficients.

TEMP is the array containing the fixed temperature profile.

DTEMDZ is the array of the values

$$\frac{1}{T(z)} \frac{dT(z)}{dz} \tag{C1}$$

DELTAZ is the array of height increments in centimeters.

SUNSET is the array containing the sunset solar zenith angle at each altitude.

GRAV is the sea level acceleration of gravity.

COSD = cos (declination)*cos (latitude).

SIND = sin (declination)*sin (latitude). Both COSD and SIND are used in computing the solar zenith angle.

TIME is the independent variable. Time is measured in seconds, with time = 0 as noontime of solution day 1.

CXI is the solar zenith angle in radians and is a function of the local time.

RADIUS is the radius of the earth in kilometers.

ISPECI is the total number of species included in the code.

KSPECI is the number of species in the transport mode.

NREAC is the number of temperature independent chemical reactions.

NREAC2 is the number of temperature dependent chemical reactions.

K is the number of height steps over which the equations are to be integrated.

KMIN1 = K - 1.

ITURB is the index of the height of the turbopause in the Z array.

CXINOON is the noontime solar zenith angle.

SCXI is the local solar zenith angle in degrees.

C1.2 Labeled COMMON

C1.2.1. COMMON/ESM/

OLDN, OLDCON, and OLDU are the extended core arrays corresponding to N, CONC, and U respectively.

RATES is the extended core array containing the values of the height dependent reaction rate constants for the 88 temperature dependent reactions. These four variables are also defined in the LEVEL statement in all programs where they apply.

C1.2.2 COMMON/TIMES/

DAYS is the variable that contains the number of solution days over which the equations will be solved.

DELT always contains the current value of the time step in seconds.

TMAX is the maximum value in seconds that the time step will be allowed to have. This value is 1800 seconds in code presented here.

TSET is the time in seconds after *noontime* of sunset at the lower boundary.

TRISE is the time in seconds after noontime of sunrise at the upper boundary.

C1.2.3 COMMON/ALTITUD/

ZBOT is the altitude of the lower boundary in kilometers.

ZTOP is the altitude of the upper boundary in kilometers.

ZTURB is the altitude of the turbopause in kilometers.

ZTRANS is the altitude of the day-night transition height. During the day, it is set at 110 km, and, during the night, it is set at 400 km.

C1.2.4 COMMON/RESTART/

IFRAME is the number given to a particular solution file on the interrupt file Tape 4. These files are numbered sequentially from 1.

TOFF is the number of seconds that must be allowed the program to dump onto the interrupt file all the information needed to restart the code at the point when it was interrupted. The final solution of these sets of equations takes many hours of CDC 7600 computer time. Because of this, the code is normally run for a few hours (usually 4), then stopped, and a dump is taken. Later, the code is restarted at this point, continued for another period of time, and another dump is taken.

This routine is repeated until the calculations reach a point where they repeat the solution over each diurnal cycle (usually about 20 days of problem time).

TYME is the time in seconds of the current computer run. The computer stops executing the code and dumps when

TYME - (time running) < TOFF.

TODAY is the date when the run was made and is printed out as XX/XX/XX.

C1.2.5 COMMON/OUTPUTS/

TIMOUT is a variable that gives the code the frequency in hours with which to send the solutions to the OUTPUT and the interrupt files. The solutions after every time step are not saved. Only those solutions occurring at TIMOUT hours and at interrupts are sent to OUTPUT and are preserved on Tape 4.

OPRINT is the variable containing the frequency in hours at which solutions are to be written on Tape 4. Except on interrupts, TIMOUT is incremented by OPRINT every time a solution set is written to Tape 4.

PRINT is a logical parameter under program control that determines whether writing to Tape 4 will take place after a solution is accepted (PRINT =.TRUE.) or will not (PRINT=.FALSE.).

C1.2.6 COMMON/ERRORS/

ERRMAX is the criterion for acceptance of a solution. When the relative change of all species at all altitudes over successive iterations is less than ERRMAX, the iteration is stopped and the solution for that time step accepted.

ERSPECI is the criterion for stopping the iteration of individual species. Since the solutions converge faster for some species than for others, a good deal of computer time can be saved by no longer iterating the equations for those species whose relative change is less than ERSPECI. Of course, ERSPECI must be much smaller than ERRMAX.

ITMAX is the maximum number of iterations to be allowed for any given solution. If any species have not converged after ITMAX iterations, the iterating is stopped and the last solutions computed are accepted. With ITMAX = 100, this situation has never arisen.

C1.2.7 COMMON/CONSTAN/

PI = 3.14159265359.

RADDEG = PI/180 is the conversion factor for degrees to radians.

DEGRAD = 180/PI is the conversion factor for radians to degrees.

RADSEC = PI/43200 is the conversion factor for changing local time in seconds to local hour angle in radians.

BOLTZ = 1.38047 x 10^{-16} ergs/K is Boltzmann's constant.

SIN2I is the square of the sine of the magnetic dip angle.

ATCON = 1.660356 x 10^{-24} is the mass of the hydrogen atom in grams.

C1.2.8 COMMON/JAYS/

The labeled COMMON/JAYS/ contains the photodissociation rate coefficients for reactions 192 through 205. The locations reserved in this labeled COMMON are initialized from file Tape 3 by PROGRAM INITIAL.

C1.2.9 COMMON/COLFRE/

The array D contains the invariant part of the collision frequencies ν_{ij}.

$$D[J,I] = \frac{1}{2}(\sigma_I + \sigma_J)^2 \left[2\pi k \frac{(m_I + m_J)}{m_I m_J}\right]^{1/2}. \qquad (C2)$$

C1.2.10 COMMON/ATCONS/

The arrays in the labeled COMMON/ATCONS/ all pertain to the atomic and molecular constants.

ATWT contains the atomic or molecular weights of the 26 species in the transport mode.

MASS=ATWT*ATCON contains the mass in grams of the 26 species in the transport mode.

THERM contains the thermal diffusion factors for the 26 species in the transport mode. Where values are not known, the thermal diffusion factor is set to zero, which removes any thermal diffusion effect for that species.

SYMBOL contains the alphanumeric identification of each of the 56 species in the model.

POLAR contains the polarizabilities of the species in the transport mode. For species whose polarizabilities are not known, the value is set to zero to remove the polarizability effect.

C1.2.11 COMMON/RATECON/

The arrays in labeled COMMON/RATECON/ all pertain to the rate coefficients for the chemical reactions.

The arrays AK, BK, and CK contain the A's, B's, and C's of Eq. (A1) for the Arrhenius dependent reaction rate coefficients.

The array DK contains the rate coefficients for the 215 chemical reactions at the particular altitude under consideration.

The array CYMB contains the alphanumeric equivalence of the 215 chemical reactions themselves.

C1.2.12 COMMON/IONS/

The arrays in labeled COMMON/IONS/ all pertain to the ionization of the atmospheric gases.

WAVE contains the alphanumeric identification of the lines or wavelength bands in the EUV.

FLUX contains the solar flux in photons/cm^2/sec/Å at the top of the atmosphere at each of the above lines or in each of the wavelength bands.

SIGMA contains the absorption and the ionization cross sections for O_2, N_2, and O, in that order.

R contains the rate coefficients for the eight energetic electron reactions at the four zenith angles and eight heights listed in Table B22.

The main overlay sets the values of the control parameters before calling OVERLAY (1,0). Upon return from OVERLAY (1,0), the initialization of the code for the run to be made is completed. The initial values of all of the dependent variables N, CONC, and U are then saved in extended core storage. Finally, OVERLAY (2,0) is called and retains control until the calculations are terminated.

C2. OVERLAY (1,0) PROGRAM INITIAL

The purpose of OVERLAY (1,0) PROGRAM INITIAL is to initialize the code for the particular run to be made. In the dimension statement—

S contains the collision cross sections in cm^2 of each of the species in the transport mode. This information is required in the computation of the collision frequencies ν_{ij}.

RMIX contains the ground level mixing ratios for the transport species.

SIG contains the photoionization cross sections for atomic nitrogen for the lines and bands given in array WAVE. These cross sections scaled by 10^{18} are listed in the DATA statement of this overlay.

Following this DATA statement are the FUNCTION definitions. The first is for the sea level value for the acceleration of gravity as a function of the latitude ϕ. It is given by[C1]

$$GRAV(\phi) = 978.0356\left[1 + 0.0052885 \sin^2(\phi) - 5.9 \times 10^{-6} \sin^2(2\phi)\right]. \qquad (C3)$$

The second is for the radius of the earth as a function of the colatitude and the sea level acceleration of gravity. It is given by[C1]

C1. List, R.J., Ed. (1963) Smithsonian Meteorological Tables, Sixth Revised Edition, Washington, D.C.

altitude whose index is IALT. First, this subroutine computes the total concentration M as

$$Y(57) = \sum_{i=i}^{56} n_i.$$

Then it moves the rate coefficients for the 215 reactions at the altitude under consideration into the K region. Following this, it ensures that the photodetachment and photodissociation of the negative ions are removed if the code is in the nighttime. The remainder of the code computes the P and L for species KIND and stores them in the appropriate FORM and REMV regions, respectively. The bulk of this subroutine as well as SUBROUTINE CHEMPR were not hand-coded for obvious reasons. To avoid the very tedious task of hand-coding these routines every time the chemistry set or the species set is changed, a set of programs was written to perform the task of writing these codes. These programs can be found in Keneshea.[3]

C.3.11 SUBROUTINE RATECN

SUBROUTINE RATECN sets the reaction rate coefficients for all the photoreactions at the altitude whose index is IALT. The first three DATA statements in this subroutine contain, respectively, the solar fluxes (x 10^{-9} photons), the ionization cross sections (x 10^{18} cm^2), and the effective absorption cross sections (x 10^{18} cm^2) for $O_2(^1\Delta g)$ as given by Huffman.[22] The next two DATA statements contain the altitudes (km) and the solar zenith angles corresponding to the input arrays of the rate coefficients for the energetic electrons. Following this is the DATA statement specifying the rate coefficient for ionization by cosmic rays. The first executable statement of the program is the FUNCTION definition for the correction at altitude ZZ for the sea level acceleration of gravity.

The code first computes all the rate coefficients for the current altitude and stores them in the DK array. On the initial call to this subroutine, the fluxes and the cross sections given in the DATA statements are scaled to their proper orders of magnitude, and the rate coefficients for the energetic electron processes are replaced by their natural logarithms. Next, the noontime values of H x F for O_2, N_2, and O are computed and saved for later use in computing the scattered radiation. Here, H is the scale height of the species and F is the Chapman approximation used in computing the absorption. If the code is in the nighttime, then transfer is made to statements near the end of the code since all photo processes are inactive during the night. If the code is in the daytime, then the photo rate coefficients are determined for the immediate daytime conditions. If the code is in the

where, as before, ℓ and $\ell + 1$ represent values at the beginning and at the end of the time step, respectively. The profile of $O(^1D)$ is computed once from Eq. (C21) each time that this subroutine is called, with P_k^{ℓ} and L_k^{ℓ} used instead of $P_k^{\ell+1}$ and $L_k^{\ell+1}$. Also computed in this subroutine are the concentrations of : (1) all the positive ions not in the transport mode; (2) all the negative species; (3) all the positive cluster ions; and (4) HNO_2 and NO_3 between 50 and 120 km.

Eq. (C21) requires the value of the chemistry terms P and L at the end of the time step which in turn require the value of n at the end of the time step. Since this is the quantity being determined, Eq. (C21) will have to be iterated. Upon each iteration, the chemistry terms are computed with the latest values of n. When the solution has converged, the value of n at $\ell + 1$ will have been achieved and the chemistry will have been computed with this value.

At the beginning of each iteration, the value of the concentration at the current altitude is saved temporarily in the array H. The new value is stored in the appropriate cell of the F array. To ensure a more rapid convergence of the solution, the value of the concentration after the current iteration is replaced by the average value

$$n = \frac{H + F}{2}$$

Then the relative difference

$$\frac{H - n}{H}$$

is computed for each species. If the relative change for each species over the current iteration is less than 20 percent, the solution is accepted for that height step and the iterations are started at the next higher altitude. If any species has a relative change greater than 20 percent, all the concentrations are iterated again. This procedure is repeated until all species have relative changes at all altitudes of less than 20 percent. The total number of iterations allowed at each altitude is 100. This number has always been more than sufficient to generate a solution.

When the concentrations of all the required species have been computed between 50 and 120 km, this subroutine then computes the electron concentration between 120 km and the upper boundary from charge balance.

C.3.13 SUBROUTINE CHEM

SUBROUTINE CHEM computes the quantities P and L for species KIND at the

The variable TIMOUT is used to keep account of the next hour in problem time when a solution will be sent to the output file. The code ensures that this time will occur exactly by resetting the time step if the current time exceeds this time. The RESET and PRINT switches are set to .TRUE., and the value of TIMOUT is incremented by OPRINT to update it for the next printout. When this routine is exited, DELT contains the time increment in seconds over which the next solution will be made, TIME contains the total elapsed problem time in seconds, and CHI contains the solar zenith angle in radians at the end of the current time step.

C3.12 SUBROUTINE CHEMION

SUBROUTINE CHEMION computes the concentrations of all species in the chemistry mode. This subroutine also computes the largest negative species from charge balance. Below 120 km, this could be a negative ion or the electrons. Above 120 km, it is always the electrons.

If the divergence of the flux in Eq. (1) is set to zero, then that equation can be written as

$$\frac{dn_i}{dt} = P_i - n_i L_i \,. \tag{C19}$$

Two convenient choices exist for solving these ordinary differential equations. They can be solved using the Kutta-Merson numerical integration scheme available in SUBROUTINE ODE, or they can be solved using simple finite differences. Since much more computer time is required to solve the equations by the Kutta-Merson scheme and since it is generally a minor species whose concentration is being computed, the more economical finite differences are used to solve Eq. (C19). Writing Eq. (C19) in finite difference notation at level k gives

$$\frac{n_k^{\ell+1} - n_k}{\Delta t} = P_k^{\ell+1} - n_k^{\ell+1} L_k^{\ell+1} \,. \tag{C20}$$

The concentration $n_k^{\ell+1}$ at the end of the time step is then

$$n_k^{\ell+1} = \frac{n_k^{\ell} + \Delta t\, P_k^{\ell+1}}{1 + \Delta t\, L_k^{\ell+1}} \tag{C21}$$

C3.8 SUBROUTINE ODE

SUBROUTINE ODE solves a set of N ordinary differential equations using the Kutta-Merson numerical integration scheme. This program is explained in detail elsewhere.[2] The solution is taken over the altitude range DZ starting at altitude SZ. The solutions are returned in array START.

C3.9 SUBROUTINE RHS

SUBROUTINE RHS is called by SUBROUTINE ODE to supply to ODE the values of the right hand side of Eq. (42). The values are computed at altitude ZE using the intermediate values v computed in SUBROUTINE ODE. The results of the evaluation are returned in the array SLOPE. The intermediate values at altitude ZE are computed using the linear interpolation coefficients derived in SUBROUTINE VELOCITY.

C3.10 SUBROUTINE COLFRE

SUBROUTINE COLFRE computes the sum of the collision frequencies (SNU) of species i with all the other species at the altitude whose index is j. It also computes the quantities $\sum_j \nu_{ij} w_j$ required in Eq. (22) for species i. In addition, it sets the values of omega (OMEG) in Eq. (17). OMEG is computed from Eq. (10) if i represents an ion, and is set equal to unity if i represents a neutral species.

C3.11 SUBROUTINE TIMER

Except for doubling of the time step after a successful integration and halving of the time step on an error, all changes to the time and the time step are done in SUBROUTINE TIMER. This subroutine decides whether or not the next integration will end at a print step. It also determines if the next time step will be in the daytime, nighttime, or in morning or evening twilight. The code advances normally in time until this subroutine determines that the sun is about to rise at the upper boundary or is about to set at the lower boundary. When either of these situations is about to happen, this subroutine adjusts the time step so that the next integration will end at the beginning of morning or evening twilight. During these twilight periods, the concentrations of some of the atmospheric species change rapidly. These changes force the code to reduce the time step to successively smaller and smaller values before a solution can be accepted. To avoid the large amount of computer time required to accompoish this, the code automatically reduces the time step to 10 seconds with the onset of morning or evening twilight. The LOGICAL switch SET controls this. The time increment is then allowed to double in PROGRAM INTEG after each successful integration until it reaches TMAX.

$$\frac{n_{j+1}}{n_j} < 100.$$

If the ratio $n_{j+1}/n_j > 100$, the velocity is set to zero at that altitude.

C3.7 SUBROUTINE VELOCITY

SUBROUTINE VELOCITY sets up the parameters required for computing the upper boundary value of the velocity of species i. In order to use any numerical integration scheme to solve Eq. (42) for the velocity w at the upper boundary, some means of interpolating values of n, P, L, and dn/dz between the upper boundary and one step below must be provided. What is used here is a simple linear interpolation:

$$\begin{cases} n_K = az_K + b \\ n_{K-1} = az_{K-1} + b \end{cases} \tag{C17}$$

Solving these equations for a and b gives

$$a = \frac{n_K - n_{K-1}}{\Delta z_K}.$$

and

$$b = \frac{n_{K-1} z_K - n_K z_{K-1}}{\Delta z_K}. \tag{C18}$$

In the function definitions at the beginning of SUBROUTINE VELOCITY, AF is the definition of a and BF is the definition of b. The subroutine then procedes to compute the a and b coefficients for the equations n(AN, BN), P(AP, BP), and L(AL, BL). These are stored in labeled COMMON/RHSIDE/ for use by SUBROUTINE RHS later. This subroutine then calls SUBROUTINE ODE to solve the ordinary differential equations Eq. (42) for species i over the last height step.

the total concentration

$$N = \sum_{i=1}^{26} n_i,$$

the mean molecular weight in grams of the atmosphere

$$\overline{m} = \frac{\rho}{N}, \tag{C15}$$

and the mean mass velocity

$$w_o = \frac{\sum_{i=1}^{26} \rho_i w_i}{\sum_{i=1}^{26} \rho_i} \tag{C16}$$

The negative ions and the positive cluster ions, which are always very minor species, are excluded from the above sums.

C3.6 SUBROUTINE EFORU

For the species whose number is ICF, SUBROUTINE EFORU computes its E and F arrays of Eq. (28) if ICF is positive, or its average velocity array from Eq. (18) if ICF is negative.

The computation of the E and F arrays is fairly straightforward. At each altitude, the A(AJ), B(BJ), C(CJ), and D(DJ) values of Eq. (21) are computed. Then the E and F arrays are computed with the upper and lower boundary conditions imposed.

The specific velocities are also calculated in this subroutine since their evaluation requires much of the same coding as do the E and F arrays. Both computations call SUBROUTINE VELOCITY to obtain the upper boundary velocity for those species that are not assumed to be in diffusive equilibrium there. To avoid unrealistically large values of the velocities when the concentration is very small, the concentration of each species n_j and the ratio of n_{j+1}/n_j are investigated at each altitude. If $n_j > 1.0 \times 10^{-10}$ cm^{-3}, then its velocity at altitude j is computed. For values of $n_j < 1.0 \times 10^{-10}$, the velocity is computed if the ratio

Performing the integration results in

$$n = n_K \exp\left\{ - \frac{mg_o}{kT_K}\left[\frac{(z - z_K)}{\left(\frac{z_K}{R} + 1\right)\left(\frac{z}{R} + 1\right)}\right]\right\} \tag{C12}$$

where the subscript K refers to quantities at the upper boundary. After the concentrations have been extrapolated to 500 km, the actual smoothing routine is called, where the profile is smoothed with a 7-point running mean. At this point, the code continues to loop back until all the required smoothing is accomplished. If no ion profile was smoothed, the subroutine is exited here. If at least one of the smoothed profiles was a positive ion profile, then the negative species must be readjusted to ensure charge neutrality in the atmosphere. Below 120 km, the largest negative species is recomputed from charge balance.

$$n_i = \sum_j n_j^+ - \sum_{j \neq i} n_j^- . \tag{C13}$$

Above 120 km the electron concentration is recomputed from

$$n_e = \sum_j n_j^+ .$$

C.4 SUBROUTINE SMOOTH

SUBROUTINE SMOOTH computes the smooth array B corresponding to the unsmoothed array A. Both arrays contain N points. M, which must be odd, is the number of points in the running mean. In this smoothing routine, the beginning and the end points are not changed.

C.5 SUBROUTINE CO

[illegible] corresponding to the index j, SUBROUTINE CO computes the [illegible] density

$$\sum_{i=1}^{20} n_i m_i \tag{C14}$$

assuming the concentration is in diffusive equilibrium above the upper boundary. That is,

$$\frac{dp}{dz} = - \rho g \tag{C6}$$

or

$$\frac{d(nkT)}{dz} = - nmg \tag{C7}$$

which reduces to

$$\frac{1}{n}\frac{dn}{dz} + \frac{1}{T}\frac{dT}{dz} = - \frac{mg}{kT} \tag{C8}$$

It is also assumed that above 400 km

$$\frac{dT}{dz} = 0.$$

Therefore, Eq. (C8) becomes

$$\frac{1}{n}\frac{dn}{dz} = - \frac{mg}{kT} \tag{C9}$$

An approximation to the acceleration of gravity at any altitude Z can be written as

$$g = \frac{g_o}{\left(1 + \frac{z}{R}\right)^2} = \frac{g_o R^2}{(R + z)^2} \tag{C10}$$

where g_o is the sea level value of the acceleration of gravity and R is the radius of the earth. Using Eq. (C10) and the assumption that the temperature is constant above the upper boundary, the solution to Eq. (C9) is

$$\ln\left(\frac{n}{n_o}\right) = - \frac{mg_o R}{kT} \int_{z_o}^{z} \frac{dz}{(R + z)^2} \tag{C11}$$

have been computed for the species in the transport mode. It then calls SUBROUTINE CHEMION to compute the concentration profiles at the end of the current time step of all the remaining species. After all the new concentrations have been computed, the code then calls SUBROUTINE EFORU to compute the average velocities for those species in the transport mode.

Following this, a check is made to see if the solution for any species has converged at all altitudes. That is, is its largest relative change less than ERSPECI. If so, its IWHICH switch is set to zero and its ITER counter set to the current iteration number. The equations for this species will be skipped on the next iteration of the equation set.

A check is then made to see if the largest relative change among all the species is less than ERRMAX. If so, the iteration loop is exited and the solution accepted for this time step. If not, transfer is made back to the beginning of the DO 130 loop for the next iteration.

When the solution is accepted, the code then asks whether or not this solution should be sent to the output file. If printing has not been requested (PRINT= .FALSE.), transfer is made to that section of the code where the time step is doubled if possible, and the new concentrations and velocities are saved in extended core storage. Transfer is then made to STATEMENT 1000, where a new solution is generated over the next time step. If the solution is to be sent to the output file, the code then calculates all the subsidiary parameters to be printed out along with the concentrations and the average velocities. The code at this point is fairly explicit as to which quantities it is computing and sending to the output file. When all the information has been sent to the output file, the code then writes an interrupt file on Tape 4. This file contains all the information necessary to restart the code at this point at some later time. Since the development of a complete time dependent solution takes many hours of CDC 6600 CP time, it has to be accomplished in many short runs (about 4 hours each). The code is restarted from Tape 4 each time.

C.3.3 SUBROUTINE SMOOTHY

SMOOTHY controls the smoothing of those profiles that PROGRAM INTEG has determined should be smoothed. If no profiles are to be smoothed (NUM=0), then the subroutine is exited immediately upon entry. Because of the nature of the smoothing process, it is necessary to extrapolate the concentration profile above the upper boundary. The altitude above the upper boundary to which the extrapolation is done should be far enough away so that the effects of the smoothing at the top of the array are not felt at the upper boundary. In this code, the profiles are extrapolated to 500 km in 1-km-height steps. The extrapolation is accomplished

solution. This may be a new solution over the next time step or another try using a smaller time step because an error was encountered.

The code then saves the time, the solar zenith angle, the day-night transition height, and the day and night logical switches at the beginning of the time step. If an error is encountered later, these parameters will have to be reinitialized. The code then calls SUBROUTINE TIMER to compute the time and solar zenith angle at the end of the current time step. It then sets the JLOOK switch depending upon whether it is day or night. Following this, the IWHICH switches are all initialized to unity and the ITER locations to 999. Then, since the equations for helium will not be solved in this calculation, its IWHICH switch is set to zero.

The statement DO 130 is the beginning of the iteration loop. The loop beginning with the next statement is taken over all the species in the transport mode. The equations will be solved over the altitude extent for each species in succession. On the first pass through the loop, the quantities

$$\frac{1}{n_e}\frac{\partial n_e}{\partial Z} \approx \frac{1}{n_e}\frac{\Delta n_e}{\Delta Z} = \frac{n_{e_j} - n_{e_{j-1}}}{n_{e_j}\,\Delta Z_{j-1}} \qquad \text{(C5)}$$

are computed and saved in the working array H. Next, the altitude dependent rate coefficients are computed using the current atmosphere and the values saved in extended core storage. If the JLOOK switch is on .TRUE., then the photodissociation rate coefficients are sent to the output file. If any of the concentration profiles need smoothing, this is done next and an acknowledgement is sent to the output file. To remain internally consistent, it is necessary now to recompute the velocity profiles for those species whose concentration profiles have been modified by smoothing. All the concentrations and velocities are then saved in extended core storage.

The code then brings into memory the values of the concentrations and velocities for the current species at the beginning of the time step. It then proceeds to compute a new concentration profile in the DO 100 loop. It also saves the largest relative change for this species in the BIGEST region. The relative change is defined as

$$\left|\frac{n_j^{\ell+1} - n_j^{\ell}}{n_j^{\ell+1}}\right|.$$

The code then loops back to solve the continuity equation for the next species in turn. When the code exits at 105 CONTINUE, all the new concentration profiles

NSPEC is an array containing the order number from 1 to 56 of each species whose concentration is to be smoothed before the iteration procedure is started. The variable NUM indicates how many profiles are to be smoothed. If NUM=0, no smoothing will be done.

Two new labeled COMMONs are defined in PROGRAM INTEG.

C3.1 Labeled COMMON/LOGIC/

All the parameters listed in Labeled COMMON/LOGIC/ are logical variables. NIGHT is .TRUE. whenever the entire altitude region between the upper and lower boundaries is in darkness. Otherwise, it is .FALSE..

DAY is .TRUE. whenever the entire altitude region between the upper and lower boundaries is in daylight. Otherwise, it is .FALSE..

Both NIGHT and DAY variables are .FALSE. when the sun is rising or setting and only part of the altitude region between the upper and lower boundaries is in darkness.

JLOOK is set to .TRUE. to send to the output file, before the iteration begins, a table of the altitude distribution of the 0_2 concentrations, the 0_2 column densities, the 0_3 concentrations, the 0_3 column densities, and the rate coefficients for all the photodissociation reactions. If JLOOK is .FALSE., this table is not printed.

RESET is set to .TRUE. in SUBROUTINE TIMER whenever the time step has been recomputed because the next solution will be sent to the output file and the interrupt file.

END is set to .TRUE. whenever the computations for the current run are to be terminated.

C3.2 Labeled COMMON/COLUM/

The Labeled COMMON/COLUM/ contains information pertaining to the photodissociation rate coefficients.

O2COL is used to transfer the 0_2 column density from SUBROUTINE DISSOC to SUBROUTINE RATECN.

O3COL is used to transfer the 0_3 column density from SUBROUTINE DISSOC to SUBROUTINE RATECN.

DIS is the array where the photodissociation information is stored in SUBROUTINE RATECN for printing in PROGRAM INTEG. To avoid excessively long printouts, only every twelfth altitude value between the lower and the upper boundaries is stored in these arrays.

PROGRAM INTEG starts by initializing some of its variables. STATEMENT 1000 CONTINUE marks the beginning of the working code. After every successful or unsuccessful solution, the code will loop back to this statement to begin the next

and (9). This overlay uses two DIMENSION statements that contain the following variables:

PHI is an array EQUIVALENCED to the array U(1, 21) and is used as temporary storage of the total flux ϕ of each species during the printout phase of the code. The array U(1, 21) would normally contain the velocity profile of helium, but, since this species is held invariant in these calculations, these memory locations are available for other uses.

DED is an array EQUIVALENCED to the array E in COMMON. It is used as temporary storage of the turbulent diffusion velocity of each species successively during the printout phase of the code.

DEDZ is an array EQUIVALENCED to the array NZERO and is used as temporary storage of the vertical gradient of the turbulent velocity for each species during the printout phase of the code.

VBAR is an array EQUIVALENCED to the array F and is used as temporary storage of the molecular diffusion velocity of each species during the printout phase of the code. The molecular diffusion velocity of a species is equal to its average velocity minus the mean mass velocity.

H is an array used in various places in the code for temporary storage of arrays.

OUTP contains four words each of which contains one hollerith character of the local time in hours. It is computed by SUBROUTINE HOUR.

IWHICH is an array of integer switches, one for each species in the transport mode. If a switch is set to 1, the equations for that species will be iterated. If the switch is set to 0, the equations for that species will not be iterated. If IWHICH (21) is set to 0 before entering the iteration loop, the concentration of helium will remain fixed at its initial value throughout the calculations since its equations will not be iterated.

ITER is an array that stores the number of iterations required by each of the sets of equations before a final solution was obtained for a given time step.

BIGEST is an array that contains the largest relative difference in each species concentration profile. It contains the maximum value of

$$\frac{n_j^{i+1} - n_j^i}{n_j^{i+1}}$$

in the array as j varies from the lower boundary to the upper boundary. This array is recomputed after each iteration.

given time. The first file, which is slightly different from all the others, must be prepared before this code is first run. It contains the initial conditions on all the dependent variables. (See the discussion on the initial conditions in Section 7.1.) Since this is an unformatted file, it must be written exactly as it is read here. First, it reads the date that the first file was written, the file number (1 in this case), and the height in kilometers of the turbopause. It then skips over six words in the file that are not necessary to the current calculations. Then it reads the number of altitude steps in the complete arrays (K = 692), the number of altitude steps in the reduced arrays (K2 = 424), and the altitude array in kilometers. After this, it reads the height step array, the fixed temperature array, the array $1/T\ dT/dZ$, and the fixed turbulent diffusion coefficient array. Next, it reads the initial velocities and initial concentrations.

In the following loop, the remainder of the interrupt files are skipped over and the tape is positioned at the beginning of a new file. At the completion of this loop, the locations containing the dependent variables will have been updated with the values obtained after the last successful solution. These values are then used as initial conditions for the next time step.

All files after file 1 on the interrupt tape are written in OVERLAY (2,0). Care must be taken not to write so many files on Tape 4 that it becomes full. Before this happens, a new Tape 4 must be made containing file 1 and the last file from the old Tape 4.

After the dependent variables have been initialized, the code initializes the solar zenith angle to the current time and computes the noontime solar zenith angle. It then reads from input Tape 5 and, where required, converts to proper units the wavelengths, solar fluxes, and absorption and ionization cross sections to be used in the photoionization calculations. Finally, from this same file, it reads the rate coefficient arrays for the energetic electron reactions. All that remains now is the calculation of the sunset (sunrise) solar zenith angles as a function of altitude. Also calculated are the times of sunset at the lower boundary and of sunrise at the upper boundary.

When all this initialization is complete, the concentration profiles corresponding to the initialized time are written to the output file. Finally, the current value of the variable TIMOUT is written to the output file in case the frequency of the output of solutions is to be changed for the next run.

C3. OVERLAY (2,0) PROGRAM INTEG

OVERLAY (2,0) contains all the programs that actually solve Eqs. (1), (7),

RADUS (GRAV, ϕ)

$$= \frac{2 \cdot \text{GRAV}}{2.27 \times 10^{-9} \cos(2\phi) - 2 \times 10^{-2} \cos(4\phi) + 3.085426 \times 10^{-6}} \quad \text{(C4)}$$

Next, the constants in labeled COMMON/CONSTAN/ are defined. After this, the constants for the particular solution to be generated are defined.

CLAT is the latitude in degrees.

DECL is the solar declination for the time of year when the calculations are to be made.

DIP is the magnetic dip angle appropriate to CLAT.

Next, the acceleration of gravity, the radius of the earth, and the constants required for later computing the solar zenith angles are computed. Information pertaining to the current calculations is then written to the output file (Tape 6).

The next section of this OVERLAY sets the chemical symbols along with the atomic or molecular weight, the mixing ratio, the collision cross section, the polarizability, and the thermal diffusion factor for the 26 transport species. Following this, the symbols for the species computed from chemistry only are written. The atomic or molecular weight of each species is then converted to mass in grams. The ground level mixing ratio of N_2 is computed to ensure that the sum of all the mixing ratios is identically unity. The mixing ratios of the species are not necessary for the code described here. However, if other initial conditions are to be computed as discussed in Keneshea et al,[8] then the values of the mixing ratios are required.

The following section of INITIAL obtains input information from various sources. The list of chemical reactions with their rate coefficients must be prepared separately and saved for use here as the file called Tape 5. This information is coded according to the FORMAT defined in statements 770 or 771, depending upon whether the reaction is not height dependent (770) or is height dependent (771). As the reactions are read in, they are also sent to the OUTPUT file (Tape 6). After the reaction set is read in, the code reads in the photodissociation rate coefficient tables (Tables B4 through B20). All values in these tables are in log base 10. These tables also are computed and saved separately. Since these numbers are functions only of the O_2 and O_3 column densities, they are universal. They need be computed only once and can then be input to any calculation regardless of geographic location, season of the year, or time of day.

After the photodissociation rate coefficients are initialized, the invariant part of the collision frequencies ν_{ij} are computed and saved in the D array.

The next section of the code reads the interrupt file Tape 4. This tape is structured in files, each containing the solution for all the dependent variables at a

morning or evening twilight periods and the current altitude is below the day-night transition altitude, then the computation of the rate coefficients is skipped. Otherwise, they are computed.

During the daytime, SUBROUTINE DISSOC is called for the computation of the photodissociation rate coefficients. These are then stored in the proper cells of the DK array. If the JLOOK switch is on .TRUE., these rate coefficients along with the concentrations and column densities of O_2 and O_3 are stored in the DIS region for later printing in the output file. Following this, the rate coefficients for the energetic electron reactions are computed. The values in the tables are interpolated to the current solar zenith angle and altitude. Next, the column densities of O_2, N_2, and O at the current solar zenith angle are approximated. These column densities are then used to compute the EUV attenuated flux at each wavelength. The rate coefficients for the photoionization processes are then computed. All EUV radiation below 0.15 nm is considered to be X radiation, which is handled differently from the longer EUV radiation. The total x-ray ionization is computed and partitioned among the species according to Swider.[19] Finally, the total EUV rate coefficients are computed as well as the rate coefficients for the ionization of nitric oxide by Lyman alpha and the ionization of $O_2(^1\Delta g)$.

If the code is in the nighttime, the above computations are skipped and the code continues from this point. The contributions of the scattered radiations to the ionization rates are computed next. Finally, the contribution of cosmic rays is added into the rate coefficients and the subroutine is exited.

C.15 FUNCTION YINT

FUNCTION YINT performs interpolation where it is required. This function essentially computes a cubic spline fit to the parameter under consideration. It then returns the interpolated value in YINT corresponding to XII in the (X, Y) arrays.

C.16 SUBROUTINE CHAPMAN

SUBROUTINE CHAPMAN computes an approximation to the Chapman function, which is required in computing the attenuation of solar energy in its transmission through the atmosphere. The approximations computed are those given by Swider and Gardner.[C2]

C2. Swider, W. Jr., and Gardner, M.E. (1967) On the Accuracy of Certain Approximations for the Chapman Function, AFCRL-67-0468, AD 658826.

C3.17 SUBROUTINE DISSOC

SUBROUTINE DISSOC returns the value of the photodissociation rate coefficients appropriate to the current solar zenith angle and the altitude whose index is IALT. The rate coefficients for all species except nitric oxide are determined as follows: The column densities of O_2 and O_3 are first approximated for the current O_2 and O_3 concentration distributions in the code. A linear interpolation is then made in the appropriate photodissociation table to determine the current photodissociation rate coefficient for each of the photodissociation processes. Finally, using the data of Cieslik and Nicolet[C3] as given in the DATA statement of this subroutine, the photodissociation rate coefficient for nitric oxide is computed.

C3.18 FUNCTION TRPLT2

FUNCTION TRPLT2 interpolates in the two-dimensional photodissociation rate coefficient tables. The two-dimensional array to be interpolated is fed to this function through the parameter ARRAY. The dimensions of ARRAY are (N, M). The indices of elements in ARRAY are IO2 and IO3. The increments required to perform the interpolation are DELO2 and DELO3.

C3.19 FUNCTION TRPLT1

FUNCTION TRPLT1 interpolates in the one-dimensional photodissociation rate coefficient tables. The array to be interpolated is fed to the function through the parameter ARRAY. The index in ARRAY is IO3 and the interpolation increment is DELO3.

C3.20 SUBROUTINE INDEX

SUBROUTINE INDEX computes an index I and an increment DEL corresponding to the column density COL. LIM is the lowest power of 10 of the column densities of O_2 and O_3 in the photodissociation tables under consideration.

C3.21 SUBROUTINE CHEMPR

Each time SUBROUTINE CHEMPR is called, it sends to the output file the complete list of chemical reactions for the altitude whose index is IZ. It also sends the rate coefficient for each reaction and its forward rate. This subroutine is also written by the WRITER codes given in Keneshea.[3] The output from this subroutine is used to determine the relative importance of the chemical reactions in different altitude regions.

C3. Cieslik, S., and Nicolet, M. (1973) The aeronomic dissociation of nitric oxide, Planet. Space Sci. 21:925-938.

C3.22 SUBROUTINE HOUR

SUBROUTINE HOUR converts the value of TIME, which is in accumulated seconds from the noontime of the day on which the simulation was started, to the local time in hours (0000 to 2359). The digits of the hour are returned in hollerith in successive words of the OUTP array.

```
      OVERLAY(ONE,0,0)
      PROGRAM MAIN(INPUT=65,OUTPUT=65,TAPE1=510,TAPE4=510,TAPE5=65,
     1             TAPE6=OUTPUT)
C
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)
C
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)
C
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2
C
      COMMON/ESM/OLDN(692,30),OLDCON(424,26),OLDU(692,26),RATES(88,692)
C
      COMMON/TIMES/DAYS,DELT,TMAX,TSET,TRISE
C
      COMMON/ALTITUD/ZBOT,ZTOP,TURB,ZTRANS
C
      COMMON/RESTART/IFRAME,TOFF,TYME,TODAY
C
      COMMON/OUTPUTS/TIMOUT,OPRINT,PRINT
C
      COMMON/ERRORS/ERRMAX,ERSPECI,ITMAX
C
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON
C
      COMMON/JAYS/J192(26,25),J193(26,26),J194(22),J195(32,28),
     1            J196(31,30),J197(27,28),J198(26,28),J200(19,15),
     2          J201(26,27),J202(22),J203(30,29),J204(35,28),J205(22)
C
      COMMON/COLFRE/D(26,26)
C
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)
C
      COMMON/RATECON/AK(88),BK(88),CK(83),DK(215),CYMB(6,215)
C
      COMMON/IONS/WAVE(88),FLUX(88),SIGMA(9,88),R(8,4,8)
C
      REAL N,NZERO
      LEVEL 3, OLDN,OLDCON,OLDU,RATES
C
C  ISPECI IS THE TOTAL NUMBER OF SPECIES IN THE MODEL.  KSPECI IS
C  THE NUMBER OF SPECIES IN THE TRANSPORT MODE WITH ALL THE
C  OTHERS IN THE CHEMISTRY MODE.
C
      ISPECI=56
      KSPECI=26
      NREAC=127
      NREAC2=68
C
C  ALTITUDES
C
      ZBOT=50.
      ZTOP=400.
      TURB=112.
      K=692
      K2=424
```

```
      C                                                                 MIONEUT    59
      C  RESTART                                                        MIONEUT    60
   60 C                                                                 MIONEUT    61
            TOFF=250.                                                   MIONEUT    62
            IFRAME=1                                                    MIONEUT    63
            TYME=14400.                                                 MIONEUT    64
            CALL DATE(TODAY)                                            MIONEUT    65
   65       WRITE(6,50) TODAY                                           MIONEUT    66
      C                                                                 MIONEUT    67
      C  TIMES                                                          MIONEUT    68
      C                                                                 MIONEUT    69
            TIME=0.                                                     MIONEUT    70
   70       TIMOUT=0.                                                   MIONEUT    71
            DELT=2.0**(-10)                                             MIONEUT    72
            TMAX=1800.                                                  MIONEUT    73
            DAYS=40.                                                    MIONEUT    74
      C                                                                 MIONEUT    75
   75 C  OUTPUTS                                                        MIONEUT    76
      C                                                                 MIONEUT    77
            OPRINT=12.                                                  MIONEUT    78
      C                                                                 MIONEUT    79
      C  ERRORS                                                         MIONEUT    80
   80 C                                                                 MIONEUT    81
            ERRMAX=0.3                                                  MIONEUT    82
            ERSPECI=0.01                                                MIONEUT    83
            ITMAX=100                                                   MIONEUT    84
      C                                                                 MIONEUT    85
   85 C*****************************************************************MIONEUT    86
      C                                                                 MIONEUT    87
            CALL OVERLAY(6HIONEUT,1,0)                                  MIONEUT    88
      C                                                                 MIONEUT    89
      C*****************************************************************MIONEUT    90
   90 C                                                                 MIONEUT    91
      C  SAVE INITIAL CONDITIONS IN ESM.                                MIONEUT    92
      C                                                                 MIONEUT    93
            CALL MOVLEV(N,OLDN,20760)                                   MIONEUT    94
            CALL MOVLEV(CONC,OLDCON,11024)                              MIONEUT    95
   95       CALL MOVLEV(U,OLDU,17992)                                   MIONEUT    96
      C                                                                 MIONEUT    97
      C START COMPUTING TIME-HEIGHT PROFILES.                           MIONEUT    98
      C                                                                 MIONEUT    99
      C*****************************************************************MIONEUT   100
  100 C                                                                 MIONEUT   101
            CALL OVERLAY(6HIONEUT,2,0)                                  MIONEUT   102
      C                                                                 MIONEUT   103
      C*****************************************************************MIONEUT   104
      C                                                                 MIONEUT   105
  105       REWIND 4                                                    MIONEUT   106
         50 FORMAT(1H1,* THIS RUN WAS MADE ON *,A10)                    MIONEUT   107
            END                                                         MIONEUT   108
```

```
      OVERLAY(1,0)                                                      IIONEUT    2
      PROGRAM INITIAL                                                   IIONEUT    3
C                                                                       IIONEUT    4
      DIMENSION S(26),RMIX(26),SIG(88)                                  IIONEUT    5
C                                                                       IIONEUT    6
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     IIONEUT    7
C                                                                       IIONEUT    8
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  IIONEUT    9
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    IIONEUT   10
C                                                                       IIONEUT   11
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      IIONEUT   12
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                         IIONEUT   13
C                                                                       IIONEUT   14
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)     IIONEUT   15
C                                                                       IIONEUT   16
      COMMON/TIMES/DAYS,DELT,TMAX,TSET,TRISE                            IIONEUT   17
C                                                                       IIONEUT   18
      COMMON/ALTITUD/ZBOT,ZTOP,TURB,ZTRANS                              IIONEUT   19
C                                                                       IIONEUT   20
      COMMON/RESTART/IFRAME,TOFF,TYME,TODAY                             IIONEUT   21
C                                                                       IIONEUT   22
      COMMON/OUTPUTS/TIMOUT,OPRINT,PRINT                                IIONEUT   23
C                                                                       IIONEUT   24
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN21,ATCON          IIONEUT   25
C                                                                       IIONEUT   26
      COMMON/JAYS/J192(26,25),J193(28,26),J194(22),J195(32,28),         IIONEUT   27
     1            J196(31,30),J197(27,28),J198(26,28),J200(19,15),      IIONEUT   28
     2            J201(26,27),J202(22),J203(30,29),J204(35,28),J205(22) IIONEUT   29
C                                                                       IIONEUT   30
      COMMON/IONS/WAVE(88),FLUX(88),SIGMA(9,88),R(8,4,8)                IIONEUT   31
C                                                                       IIONEUT   32
      COMMON/RATECON/AK(88),BK(88),CK(88),DK(215),CYMB(6,215)           IIONEUT   33
C                                                                       IIONEUT   34
      COMMON/COLFRE/D(26,26)                                            IIONEUT   35
C                                                                       IIONEUT   36
      REAL N,MASS,J192,J193,J194,J195,J196,J197,J198,J200,J201,J202     IIONEUT   37
      REAL J203,J204,J205                                               IIONEUT   38
C                                                                       IIONEUT   39
C  THE FOLLOWING DATA STATMENT CONTAINS THE PHOTOIONIZATION             IIONEUT   40
C  CROSS SECTIONS FOR ATOMIC NITROGEN SCALED BY 1E18.                   IIONEUT   41
C  SEE "AERONOMY" BY BANKS AND KOCHARTS, PART A, P102-104.              IIONEUT   42
C                                                                       IIONEUT   43
      DATA SIG/21*(0.),20*(10.0),2*(10.5),2*(10.4),10.75,4*(11.0),      IIONEUT   44
     1        11.8,11.9,2*(12.0),11.9,11.5,11.1,11.0,9.3,10.0,9.7,      IIONFUT   45
     2        8.5,8.8,2*(8.0),7.3,6.7,6.0,5.3,6.3,4.3,3.4,2.8,2.2,1.3,  IIONEUT   46
     3        0.58,0.45,0.36,0.32,0.23,0.16,0.093,0.04,0.03,0.015,      IIONEUT   47
     4        0.006,0.001,0.0001/                                       IIONEUT   48
C                                                                       IIONEUT   49
C  FUNCTION DEFINITION FOR SEA LEVEL ACCELERATION OF GRAVITY AS         IIONEUT   50
C  A FUNCTION OF LATITUDE IN CM/SEC**2.                                 IIONEUT   51
C                                                                       IIONEUT   52
      GRAVTY(ALAT)=978.0356*(1.0+0.0052885*(SIN(ALAT))**2               IIONEUT   53
     1             -5.9E-06*(SIN(2.0*ALAT))**2)                         IIONEUT   54
C                                                                       IIONEUT   55
C  FUNCTION DEFINITION FOR RADIUS OF THE EARTH IN KILOMETERS AS         IIONEUT   56
C  A FUNCTION OF LATITUDE AND SEA LEVEL GRAVITY.                        IIONEUT   57
C                                                                       IIONEUT   58
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      RADUS(GRAV,ALAT)=(2.0*GRAV*1.0E-5)/(2.27E-09*COS(2.0*ALAT)      IIONEUT    59
     1                -2.0E-12*COS(4.0*ALAT)+3.085462E-06)            IIONEUT    60
C                                                                     IIONEUT    61
C  CONSTANTS                                                          IIONEUT    62
C                                                                     IIONEUT    63
      PI=3.14159265359                                                IIONEUT    64
      RADDEG=PI/180.                                                  IIONEUT    65
      DEGRAD=180./PI                                                  IIONEUT    66
      RADSEC=PI/43200.                                                IIONEUT    67
      BOLTZ=1.38047E-16                                               IIONEUT    68
C                                                                     IIONEUT    69
C  SET CONSTANTS FOR PARTICULAR MODEL CALCULATION.                    IIONEUT    70
C                                                                     IIONEUT    71
      CLAT=30.0                                                       IIONEUT    72
      DECL=-19.55                                                     IIONEUT    73
      DIP=60.0                                                        IIONEUT    74
      PHILAT=CLAT*RADDEG                                              IIONEUT    75
      GRAV=GRAVTY(PHILAT)                                             IIONEUT    76
      RADIUS=RADUS(GRAV,PHILAT)                                       IIONEUT    77
      DECLAT=DECL*RADDEG                                              IIONEUT    78
      COSD=COS(DECLAT)*COS(PHILAT)                                    IIONEUT    79
      SIND=SIN(DECLAT)*SIN(PHILAT)                                    IIONEUT    80
      SIN2I=(SIN(DIP*RADDEG))**2                                      IIONEUT    81
      WRITE(6,25) CLAT,DECL,DIP,GRAV,RADIUS                           IIONEUT    82
   25 FORMAT(1H0,5X,"LATITUDE OF MODEL =",0PF6.2," DEGREES."/         IIONEUT    83
     16X,"SOLAR DECLINATION =",F6.2," DEGREES."/6X,"MAGNETIC DIP ",   IIONEUT    84
     2"ANGLE =",F6.2," DEGREES."/6X,"ACCELERATION OF GRAVITY =",1PE12.5,  IIONEUT    85
     3" CM/SEC**2."/6X,"RADIUS OF THE EARTH =",E12.5," KM.")          IIONEUT    86
C                                                                     IIONEUT    87
C  SET ATOMIC AND MOLECULAR WEIGHTS, MIXING RATIOS, COLLISION CROSS   IIONEUT    88
C  SECTIONS. THERMAL DIFFUSION FACTORS AND POLARIZABILITIES.          IIONEUT    89
C                                                                     IIONEUT    90
      ATCON=1.66035E-24                                               IIONEUT    91
      DO 60 I=1,KSPECI                                                IIONEUT    92
      THERM(I)=1.0                                                    IIONEUT    93
      POLAR(I)=0.0                                                    IIONEUT    94
       RMIX(I)=0.0                                                    IIONEUT    95
   60 CONTINUE                                                        IIONEUT    96
      SYMBOL(1)=10H H+                                                IIONEUT    97
        ATWT(1)=1.00797                                               IIONEUT    98
           S(1)=3.04E-08                                              IIONEUT    99
      SYMBOL(2)=10H HE+                                               IIONEUT   100
        ATWT(2)=4.0026                                                IIONEUT   101
           S(2)=2.04E-08                                              IIONEUT   102
      SYMBOL(3)=10H O+                                                IIONEUT   103
        ATWT(3)=15.9994                                               IIONEUT   104
           S(3)=1.2E-08                                               IIONEUT   105
      SYMBOL(4)=10H O2+                                               IIONEUT   106
        ATWT(4)=31.9988                                               IIONEUT   107
           S(4)=3.3E-08                                               IIONEUT   108
      SYMBOL(5)=10H NO+                                               IIONEUT   109
        ATWT(5)=30.006132                                             IIONEUT   110
           S(5)=3.4E-08                                               IIONEUT   111
      SYMBOL(6)=10H N+                                                IIONEUT   112
        ATWT(6)=14.006732                                             IIONEUT   113
           S(6)=1.42E-08                                              IIONEUT   114
      SYMBOL(7)=10H O                                                 IIONEUT   115
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      THERM(7)[illegible]                                            IIO[illegible]   11[illegible]
      POLAR(7)[illegible]                                            IIONEUT  117
       ATWT(7)=[illegible]998                                        IIONEUT  118
       RMIX(7)=[illegible]19E-08                                     IIONEUT  119
          S(7)=2.65E-08                                              IIONEUT  120
      SYMBOL(8)=10H O2                                               IIONEUT  121
      THERM(8)=1.0+0.[illegible]                                     IIONEUT  122
      POLAR(8)=1.59                                                  IIONEUT  123
       ATWT(8)=31.9988                                               IIONEUT  124
       RMIX(8)=0.209545                                              IIONEUT  125
          S(8)=3.40E-08                                              IIONEUT  126
      SYMBOL(9)=10H O3                                               IIONEUT  127
       ATWT(9)=47.9982                                               IIONEUT  128
       RMIX(9)=7.0E-06                                               IIONEUT  129
          S(9)=4.0E-08                                               IIONEUT  130
      SYMBOL(10)=10H OH                                              IIONEUT  131
       ATWT(10)=17.00737                                             IIONEUT  132
       RMIX(10)=1.0E-10                                              IIONEUT  133
          S(10)=3.0E-08                                              IIONEUT  134
      SYMBOL(11)=10H H                                               IIONEUT  135
       THERM(11)=1.0-0.39                                            IIONEUT  136
       POLAR(11)=0.667                                               IIONEUT  137
       ATWT(11)=1.00797                                              IIONEUT  138
       RMIX(11)=1.6E-13                                              IIONEUT  139
          S(11)=3.04E-08                                             IIONEUT  140
      SYMBOL(12)=10H HO2                                             IIONEUT  141
       ATWT(12)=33.00677                                             IIONEUT  142
       RMIX(12)=1.0E-12                                              IIONEUT  143
          S(12)=4.0E-08                                              IIONEUT  144
      SYMBOL(13)=10H H2O                                             IIONEUT  145
       ATWT(13)=18.01534                                             IIONEUT  146
       RMIX(13)=5.0E-06                                              IIONEUT  147
          S(13)=3.5E-08                                              IIONEUT  148
      SYMBOL(14)=10H H2O2                                            IIONEUT  149
       ATWT(14)=34.01474                                             IIONEUT  150
       RMIX(14)=1.0E-10                                              IIONEUT  151
          S(14)=4.0E-08                                              IIONEUT  152
      SYMBOL(15)=10H H2                                              IIONEUT  153
       THERM(15)=1.0-0.31                                            IIONEUT  154
       POLAR(15)=0.82                                                IIONEUT  155
       ATWT(15)=2.01594                                              IIONEUT  156
       RMIX(15)=4.5E-07                                              IIONEUT  157
          S(15)=2.97E-08                                             IIONEUT  158
      SYMBOL(16)=10H N                                               IIONEUT  159
       POLAR(16)=1.1                                                 IIONEUT  160
       ATWT(16)=14.006732                                            IIONEUT  161
       RMIX(16)=1.0E-11                                              IIONEUT  162
          S(16)=1.42E-08                                             IIONEUT  163
      SYMBOL(17)=10H N2D                                             IIONEUT  164
       POLAR(17)=1.1                                                 IIONEUT  165
       ATWT(17)=14.006732                                            IIONEUT  166
       RMIX(17)=1.0E-16                                              IIONEUT  167
          S(17)=1.42E-08                                             IIONEUT  168
      SYMBOL(18)=10H NO                                              IIONEUT  169
       POLAR(18)=1.74                                                IIONEUT  170
       ATWT(18)=30.00[illegible]32                                   IIONEUT  171
       RMIX(18)=1.0E-11                                              IIONEUT  172
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      S(18)=3.4E-08                                                     IIONEUT  173
     SYMBOL(19)=10H NO2                                                 IIONEUT  174
       ATWT(19)=46.005532                                               IIONEUT  175
       RMIX(19)=1.0E-11                                                 IIONEUT  176
          S(19)=3.8E-08                                                 IIONEUT  177
     SYMBOL(20)=10H O21D                                                IIONEUT  178
      POLAR(20)=1.59                                                    IIONEUT  179
       ATWT(20)=31.9988                                                 IIONEUT  180
       RMIX(20)=2.0E-06                                                 IIONEUT  181
          S(20)=3.3E-08                                                 IIONEUT  182
     SYMBOL(21)=10H HELIUM                                              IIONEUT  183
      THERM(21)=1.0-0.36                                                IIONEUT  184
      POLAR(21)=0.21                                                    IIONEUT  185
       ATWT(21)=4.0026                                                  IIONEUT  186
       RMIX(21)=5.24E-06                                                IIONEUT  187
          S(21)=2.04E-08                                                IIONEUT  188
     SYMBOL(22)=10H ARGON                                               IIONEUT  189
       ATWT(22)=39.948                                                  IIONEUT  190
       RMIX(22)=0.00934                                                 IIONEUT  191
          S(22)=2.97E-08                                                IIONEUT  192
     SYMBOL(23)=10H N2                                                  IIONEUT  193
      POLAR(23)=1.76                                                    IIONEUT  194
       ATWT(23)=28.013464                                               IIONEUT  195
       RMIX(23)=0.78                                                    IIONEUT  196
          S(23)=3.15E-08                                                IIONEUT  197
     SYMBOL(24)=10H N2O                                                 IIONEUT  198
      POLAR(24)=3.00                                                    IIONEUT  199
       ATWT(24)=44.012864                                               IIONEUT  200
       RMIX(24)=2.7E-07                                                 IIONEUT  201
          S(24)=3.7E-08                                                 IIONEUT  202
     SYMBOL(25)=10H CO2                                                 IIONEUT  203
      POLAR(25)=2.63                                                    IIONEUT  204
       ATWT(25)=44.00995                                                IIONEUT  205
       RMIX(25)=3.14E-04                                                IIONEUT  206
          S(25)=3.8E-08                                                 IIONEUT  207
     SYMBOL(26)=10H CO                                                  IIONEUT  208
      POLAR(26)=1.97                                                    IIONEUT  209
       ATWT(26)=28.01055                                                IIONEUT  210
       RMIX(26)=1.0E-08                                                 IIONEUT  211
          S(26)=3.0E-08                                                 IIONEUT  212
C                                                                       IIONEUT  213
C  THE FOLLOWING SPECIES ARE COMPUTED FROM CHEMISTRY ONLY.              IIONEUT  214
C                                                                       IIONEUT  215
      SYMBOL(27)=10H O1D                                                IIONEUT  216
      SYMBOL(28)=10H N2+                                                IIONEUT  217
      SYMBOL(29)=10H O+(2D)                                             IIONEUT  218
      SYMBOL(30)=10H E                                                  IIONEUT  219
      SYMBOL(31)=10H O-                                                 IIONEUT  220
      SYMBOL(32)=10H O2-                                                IIONEUT  221
      SYMBOL(33)=10H O3-                                                IIONEUT  222
      SYMBOL(34)=10H O4-                                                IIONEUT  223
      SYMBOL(35)=10H NO2-                                               IIONEUT  224
      SYMBOL(36)=10H NO3-                                               IIONEUT  225
      SYMBOL(37)=10H CO3-                                               IIONEUT  226
      SYMBOL(38)=10H CO4-                                               IIONEUT  227
      SYMBOL(39)=10H O4+                                                IIONEUT  228
      SYMBOL(40)=10H NO2+                                               IIONEUT  229
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      SYMBOL(41)=10H H3O+                                                IIONEUT  230
      SYMBOL(42)=10H H5O2+                                               IIONEUT  231
      SYMBOL(43)=10H H7O3+                                               IIONEUT  232
      SYMBOL(44)=10H H9O4+                                               IIONEUT  233
      SYMBOL(45)=10H H11O5+                                              IIONEUT  234
      SYMBOL(46)=10H H3O+.N2                                             IIONEUT  235
      SYMBOL(47)=10H H3O+.OH                                             IIONEUT  236
      SYMBOL(48)=10H H3O+.CO2                                            IIONEUT  237
      SYMBOL(49)=10H H5O2+.CO2                                           IIONEUT  238
      SYMBOL(50)=10H O2+.H2O                                             IIONEUT  239
      SYMBOL(51)=10H NO+.H2O                                             IIONEUT  240
      SYMBOL(52)=10H NO+.2H2O                                            IIONEUT  241
      SYMBOL(53)=10H NO+.3H2O                                            IIONEUT  242
      SYMBOL(54)=10H NO+.CO2                                             IIONEUT  243
      SYMBOL(55)=10H HNO2                                                IIONEUT  244
      SYMBOL(56)=10H NO3                                                 IIONEUT  245
      SUMMIX=0.                                                          IIONEUT  246
      DO 2 I=1,KSPECI                                                    IIONEUT  247
      MASS(I)=ATWT(I)*ATCON                                              IIONEUT  248
      IF(I .EQ. 23) GO TO 2                                              IIONEUT  249
      SUMMIX=SUMMIX+RMIX(I)                                              IIONEUT  250
2     CONTINUE                                                           IIONEUT  251
      RMIX(23)=1.0-SUMMIX                                                IIONEUT  252
C                                                                        IIONEUT  253
C  READ CHEMICAL REACTIONS AND RATE CONSTANTS.                           IIONEUT  254
C                                                                        IIONEUT  255
      WRITE(6,650)                                                       IIONEUT  256
650   FORMAT(1H0,*  THE CHEMICAL REACTIONS USED IN THIS RUN ARE:*)       IIONEUT  257
      DO 765 J=1,NREAC                                                   IIONEUT  258
      READ(5,770) IREAC,(CYMB(I,J),I=1,6),DK(J)                          IIONEUT  259
770   FORMAT(I3,5A10,A5,1PE8.2)                                          IIONEUT  260
      WRITE(6,771) IREAC,(CYMB(I,J),I=1,6),DK(J)                         IIONEUT  261
771   FORMAT(2X,I3,5A10,A5,1PE9.2)                                       IIONEUT  262
  765 CONTINUE                                                           IIONEUT  263
      DO 35 J=1,NREAC2                                                   IIONEUT  264
      READ(5,772) IREAC,(CYMB(I,NREAC+J),I=1,6),AK(J),BK(J),CK(J)        IIONEUT  265
772   FORMAT(I3,5A10,A5,1PE8.2,0PF5.2,1PE9.2)                            IIONEUT  266
      WRITE(6,773) IREAC,(CYMB(I,NREAC+J),I=1,6),AK(J),BK(J),CK(J)       IIONEUT  267
773   FORMAT(2X,I3,5A10,A5,1PE9.2,0PF6.2,1PE10.2)                        IIONEUT  268
35    CONTINUE                                                           IIONEUT  269
C                                                                        IIONEUT  270
C  READ PHOTODISSOCIATION RATE COEFFICIENTS AS LOG BASE 10.              IIONEUT  271
C                                                                        IIONEUT  272
      REWIND 3                                                           IIONEUT  273
      READ(3) ((J193(L,M),L=1,28),M=1,26)                                IIONEUT  274
      READ(3) ((J192(L,M),L=1,26),M=1,25)                                IIONEUT  275
      READ(3) ((J196(L,M),L=1,31),M=1,30)                                IIONEUT  276
      READ(3) ((J197(L,M),L=1,27),M=1,28)                                IIONEUT  277
      READ(3) ((J195(L,M),L=1,32),M=1,28)                                IIONEUT  278
      READ(3) (J194(L),L=1,22)                                           IIONEUT  279
      READ(3) ((J200(L,M),L=1,19),M=1,15)                                IIONEUT  280
      READ(3) (J205(L),L=1,22)                                           IIONEUT  281
      READ(3) ((J201(L,M),L=1,26),M=1,27)                                IIONEUT  282
      READ(3) ((N(L,M),L=1,26),M=1,25)                                   IIONEUT  283
      READ(3) (J202(L),L=1,22)                                           IIONEUT  284
      READ(3) ((N(L,M),L=1,26),M=1,23)                                   IIONEUT  285
      READ(3) ((N(L,M),L=1,30),M=1,30)                                   IIONEUT  286
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      READ(3) ((J203(L,M),L=1,30),M=1,29)                                IIONEUT  287
      READ(3) ((J204(L,M),L=1,35),M=1,28)                                IIONEUT  288
      READ(3) ((N(L,M),L=1,37),M=1,20)                                   IIONEUT  289
      READ(3) ((J198(L,M),L=1,26),M=1,28)                                IIONEUT  290
290   C                                                                  IIONEUT  291
C     COMPUTE INVARIANT PART OF COLLISION FREQUENCIES.                   IIONEUT  292
C                                                                        IIONEUT  293
      DO 22 I=1,KSPECI                                                   IIONEUT  294
      DO 22 J=1,KSPECI                                                   IIONEUT  295
295   D(J,I)=0.5*((S(I)+S(J))**2)*SQRT(2.0*PI*BOLTZ*((MASS(I)+MASS(J))   IIONEUT  296
     1       /(MASS(I)*MASS(J))))                                        IIONEUT  297
22    CONTINUE                                                           IIONEUT  298
      IFRAM=IFRAME-1                                                     IIONEUT  299
      REWIND 4                                                           IIONEUT  300
300   READ(4) DATEOF,IFRAME,TURB,(N(J,1),J=1,6),K,K2,(Z(J),J=1,K)        IIONEUT  301
      READ(4) (DELTAZ(L),L=1,K)                                          IIONEUT  302
      READ(4) (TEMP(L),L=1,K)                                            IIONEUT  303
      READ(4) (DTEMDZ(L),L=1,K)                                          IIONEUT  304
      READ(4) (DEDY(L),L=1,K)                                            IIONEUT  305
305   DO 1 J=1,K                                                         IIONEUT  306
      DEDY(J)=3.0*DEDY(J)                                                IIONEUT  307
1     CONTINUE                                                           IIONEUT  308
      DO 5 L=1,KSPECI                                                    IIONEUT  309
      READ(4) (U(J,L),J=1,K)                                             IIONEUT  310
310   5     CONTINUE                                                     IIONEUT  311
      DO 20 L=1,ISPECI                                                   IIONEUT  312
      IF(L .GT. 30) GO TO 10                                             IIONEUT  313
      READ(4) (N(J,L),J=1,K)                                             IIONEUT  314
      GO TO 20                                                           IIONEUT  315
315   10    READ(4) (CONC(J,L-30),J=1,K2)                                IIONEUT  316
20    CONTINUE                                                           IIONEUT  317
      KMIN1=K-1                                                          IIONEUT  318
13    READ(4)                                                            IIONEUT  319
      IF(EOF(4)) 14,13                                                   IIONEUT  320
320   14    IF(IFRAM .EQ. 0) GO TO 15                                    IIONEUT  321
      DO 140 I=1,IFRAM                                                   IIONEUT  322
      READ(4) DATEOF,IFRAME,TIME,SCXI,CXI,DELT,TIMOUT                    IIONEUT  323
      DO 18 L=1,KSPECI                                                   IIONEUT  324
      READ(4) (U(J,L),J=1,K)                                             IIONEUT  325
325   18    CONTINUE                                                     IIONEUT  326
      DO 19 L=1,ISPECI                                                   IIONEUT  327
      IF(L .GT. 30) GO TO 11                                             IIONEUT  328
      READ(4) (N(J,L),J=1,K)                                             IIONEUT  329
      GO TO 19                                                           IIONEUT  330
330   11    READ(4) (CONC(J,L-30),J=1,K2)                                IIONEUT  331
19    CONTINUE                                                           IIONEUT  332
16    READ(4)                                                            IIONEUT  333
      IF(EOF(4)) 140,16                                                  IIONEUT  334
140   CONTINUE                                                           IIONEUT  335
335   15    CXI=ACOS(COSD*COS(RADSEC*TIME)+SIND)                         IIONEUT  336
      CXINOON=ACOS(COSD+SIND)                                            IIONEUT  337
      SCXI=CXI*DEGRAD                                                    IIONEUT  338
      DO 4 J=1,K                                                         IIONEUT  339
      IF(Z(J) .GT. TURB) GO TO 6                                         IIONEUT  340
340   4     CONTINUE                                                     IIONEUT  341
6     ITURB=J-1                                                          IIONEUT  342
C                                                                        IIONEUT  343
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C  READ WAVELENGTH, FLUX AND CROSS SECTION DATA FOR PHOTOIONIZATION.
C
      READ(5,200) (WAVEL(L),FLUX(L),(SIGMA(I,L),I=1,8),L=1,88)
200   FORMAT(A8,9E8.4)
      READ(5,205) (FLUX(J),J=84,88)
205   FORMAT(5E8.2
      DO 220 L=1,88
      IF(L .GE. 84) GO TO 210
      FLUX(L)=FLUX(L)*1.0E+09
210   DO 215 I=1,8
      SIGMA(I,L)=SIGMA(I,L)*1.0E-18
215   CONTINUE
      SIGMA(9,L)=SIG(L)*1.0E-18
220   CONTINUE
C
C  READ RATE COEFFICIENTS FOR ENERGETIC ELECTRON REACTIONS.
C
      READ(5,225) (((R(J,I,L),J=1,8),I=1,4),L=1,8)
225   FORMAT(1P4E12.5)
C
C  COMPUTE SUNSET CHI ANGLES AS A FUNCTION OF ALTITUDE AND TIME
C  OF SUNSET(TSET) AT THE LOWER BOUNDARY AND TIME OF SUNRISE AT THE
C  UPPER BOUNDARY(TRISE).  TIMES ARE IN SECONDS AFTER NOONTIME.
C
C     GEORAD  = GEOMETRIC RADIUS OF EARTH IN KM
C               USE SWIDER PLANET SPACE SCI 1964,V12,P766,TABLE 1
C               ASSUME EARTH LOCALLY SPHERICAL FOR SUNSET/SUNRISE
C               (NEGLECT LATITUDE CHANGE WHERE RAYPATH TANGENT EARTH)
C
      AE=6378.4
      AP = 6356.9
      GEORAD=AE/SQRT(1.0+(((AE/AP)**2-1.0)*SIN(PHILAT)**2))
      DO 3015 J=1,K
      SUNSET(J)=(PI/2.0)+ACOS(1.0/(1.0+Z(J)/GEORAD))
      EPSILON=2.0**(-20)
3025  TS=(ACOS((COS(SUNSET(J))-SIND)/COSD)/RADSEC)+EPSILON
      TR=86400.-TS+2.0*EPSILON
      CHIS=ACOS(COSD*COS(RADSEC*TS)+SIND)
      IF(CHIS .GT. SUNSET(J)) GO TO 3027
3026  EPSILON=2*EPSILON
      GOTO 3025
3027  CHIR=ACOS(COSD*COS(RADSEC*TR)+SIND)
      IF(CHIR .GE. SUNSET(J)) GO TO 3026
      IF(J .EQ. 1) TSET=TS
      IF(J .EQ. K) TRISE=TR
3015  CONTINUE
C
C WRITE OUT INITIAL PROFILES.
C
      N1=1
      N2=11
      DO 100 L=1,2
      WRITE(6,605)
      WRITE(6,315) TIME,SCXI,IFRAME
      WRITE(6,610) (SYMBOL(M),M=N1,N2)
      WRITE(6,320) (Z(J),(N(J,M),M=N1,N2),J=1,K,12)
      WRITE(6,320) Z(K),(N(K,M),M=N1,N2)
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      N1=12                                                              IIONEUT   401
      N2=22                                                              IIONEUT   402
  100 CONTINUE                                                           IIONEUT   403
      WRITE(6,605)                                                       IIONEUT   404
      WRITE(6,315) TIME,SCXI,IFRAME                                      IIONEUT   405
      WRITE(6,611) (SYMBOL(J),J=23,30)                                   IIONEUT   406
      WRITE(6,320) (Z(J),(N(J,I),I=23,30),TEMP(J),DTEMDZ(J),DEDY(J),     IIONEUT   407
     1J=1,K,12)                                                          IIONEUT   408
      WRITE(6,320) Z(KMIN1),(N(KMIN1,I),I=23,30),TEMP(KMIN1),            IIONEUT   409
     1DTEMDZ(KMIN1),DEDY(KMIN1)                                          IIONEUT   410
      WRITE(6,320) Z(K),(N(K,I),I=23,30),TEMP(K),DTEMDZ(K),DEDY(K)       IIONEUT   411
  611 FORMAT(*  ALT(KM)*,4X,8A10,*TEMP     (1/T)DT/DZ  K-EDDY*)         IIONEUT   412
      WRITE(6,605)                                                       IIONEUT   413
      WRITE(6,315) TIME,SCXI,IFRAME                                      IIONEUT   414
      WRITE(6,125) (SYMBOL(M),M=31,43)                                   IIONEUT   415
  125 FORMAT(*  ALT(KM)*,13A9)                                           IIONEUT   416
      WRITE(6,130) (Z(J),(CONC(J,M),M=1,13),J=1,K2,12)                   IIONEUT   417
      WRITE(6,130) Z(K2),(CONC(K2,M),M=1,13)                             IIONEUT   418
  130 FORMAT(0PF8.2,1X,1P13E9.2)                                         IIONEUT   419
      WRITE(6,605)                                                       IIONEUT   420
      WRITE(6,315) TIME,SCXI,IFRAME                                      IIONEUT   421
      WRITE(6,125) (SYMBOL(M),M=44,56)                                   IIONEUT   422
      WRITE(6,130) (Z(J),(CONC(J,M),M=14,26),J=1,K2,12)                  IIONEUT   423
      WRITE(6,130) Z(K2),(CONC(K2,M),M=14,26)                            IIONEUT   424
  605 FORMAT(1H1,60X17HINITIAL PROFILES.)                                IIONEUT   425
  610 FORMAT(*  ALT(KM)*,11A10)                                          IIONEUT   426
  315 FORMAT(1H ,10X,*TIME =*,1PE12.5,* SEC.*,10X,*CXI =*,E12.5,         IIONEUT   427
     1* DEGREES.*,10X,*FRAME NO.*,I4)                                    IIONEUT   428
  320 FORMAT(0PF8.2,2X,1P11E10.3)                                        IIONEUT   429
      WRITE(6,325) TIMOUT                                                IIONEUT   430
  325 FORMAT(1H0,*  TIMOUT =*,1PE13.5)                                   IIONEUT   431
      END                                                                IIONEUT   432
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      OVERLAY(2,0)                                                      GIONEUT     2
      PROGRAM INPES                                                     GIONEUT     3
C                                                                       GIONEUT     4
      DIMENSION PHI(1),DED(1),DEDZ(1),DFDZ(1),VBAR(1),H(692)            GIONEUT     5
      DIMENSION OUT(4),IWHICH(26),ITER(26),BIGEST(26),NSPEC(56)         GIONEUT     6
C                                                                       GIONEUT     7
      COMMON N(692,26),CO(1),CONC(424,26),U(692,26),NZERO(692),UZERO(692) GIONEUT   8
C                                                                       GIONEUT     9
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT    10
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT    11
C                                                                       GIONEUT    12
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT    13
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                         GIONEUT    14
C                                                                       GIONEUT    15
      COMMON/ESN/OLDN(692,30),OLDCON(424,26),OLDU(692,26),RATES(88,692) GIONEUT   16
C                                                                       GIONEUT    17
      COMMON/TIMES/DAYS,DELT,TMAX,TSET,TRISE                            GIONEUT    18
C                                                                       GIONEUT    19
      COMMON/ALTITUD/ZSCL,ZTOP,TURB,ZTRANS                              GIONEUT    20
C                                                                       GIONEUT    21
      COMMON/RESTART/IFRAME,TOFF,TYME,TODAY                             GIONEUT    22
C                                                                       GIONEUT    23
      COMMON/OUTPUTS/TIMOUT,OPRINT,PRINT                                GIONEUT    24
C                                                                       GIONEUT    25
      COMMON/ERRORS/ERRMAX,ERSPECI,ITMAX                                GIONEUT    26
C                                                                       GIONEUT    27
      COMMON/LOGIC/NIGHT,DAY,JLOOK,RESET,END                            GIONEUT    28
C                                                                       GIONEUT    29
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)    GIONEUT    30
C                                                                       GIONEUT    31
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,AYCON          GIONEUT    32
C                                                                       GIONEUT    33
      COMMON/COLUM/O2COL,O3COL,DIS(19,59)                               GIONEUT    34
C                                                                       GIONEUT    35
      COMMON/RATECON/AK(88),BK(88),CK(88),DK(215),CYMB(6,215)           GIONEUT    36
C                                                                       GIONEUT    37
      LEVEL 3, OLDN,OLDCON,OLDU,RATES                                   GIONEUT    38
      REAL N,NZERO,NEWN,MASS,MBAR,NTOTAL                                GIONEUT    39
      LOGICAL JLOOK,NIGHT,DAY,RESET,PRINT,END,LASTNT,LASTDA             GIONEUT    40
      EQUIVALENCE (U(1,21),H,PHI),(E,DED),(F,VBAR),(NZERO,DEDZ)         GIONEUT    41
      EQUIVALENCE (UZERO,DFDZ)                                          GIONEUT    42
C                                                                       GIONEUT    43
      DATA NSWITCH/1/                                                   GIONEUT    44
C                                                                       GIONEUT    45
C  FUNCTION DEFINITION FOR CORRECTION TO ACCELERATION OF GRAVITY.       GIONEUT    46
C                                                                       GIONEUT    47
      GRAVCOR(ZZ)=1.0/((1.0+ZZ/RADIUS)**2)                              GIONEUT    48
C                                                                       GIONEUT    49
C  IF ANY SMOOTHING IS TO BE DONE, SET NUM TO THE NUMBER OF SPECIES     GIONEUT    50
C  TO BE SMOOTHED AND PUT THEIR SPECI NUMBERS INTO THE NSPEC REGION.    GIONEUT    51
C  IF NO SMOOTHING IS TO BE DONE, SET NUM TO ZERO.                      GIONEUT    52
C                                                                       GIONEUT    53
      NUM=0                                                             GIONEUT    54
      END=.FALSE.                                                       GIONEUT    55
      JLOOK=.TRUE.                                                      GIONEUT    56
      DAY=(TIME.LT.SUNSET(1))                                           GIONEUT    57
      NIGHT=(TIME.GT.SUNSET(K))                                         GIONEUT    58
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      EDDYL=EDDY                                                        GIONEUT  814
      EDDY=DEDY(J)                                                      GIONEUT  815
      DZDZ=1.0/(DZ*DZL)                                                 GIONEUT  816
      DZODZL=DZ/DZL                                                     GIONEUT  817
      IF(J .GT. ITLRB) GO TO 15                                         GIONEUT  818
      TTL=0.                                                            GIONEUT  819
      WBAR=0.                                                           GIONEUT  820
      DO 10 L=1,KSPECI                                                  GIONEUT  821
      EN=N(J,L)                                                         GIONEUT  822
      WBAR=WBAR+MASS(L)*EN                                              GIONEUT  823
      TTL=TTL+EN                                                        GIONEUT  824
   10 CONTINUE                                                          GIONEUT  825
      WBAR=WBAR/TTL                                                     GIONEUT  826
      GAMBAL=GAMBA                                                      GIONEUT  827
      GAMBA=1.0-(DLNTDZ+GRAV*GCRN*WBAR/(BOLTZ*T))*DZ                    GIONEUT  828
   15 DTDZ=DELT*DZDZ                                                    GIONEUT  829
      IF(J .EQ. 1) GO TO 20                                             GIONEUT  830
      AJ=DTDZ*(PJ*DTKTM+EDDY)                                           GIONEUT  831
      BJ=1.0+DTDZ*(PJ*(UJL*DZ+DTKTM*GAM)+PJL*DTKTML*DZODZL              GIONEUT  832
     1    +EDDY*GAMBA+EDDYL*DZODZL)+(REMV(J)+PJ*SNUW*DELT/DZL)*DELT     GIONEUT  833
      CJ=DTDZ*(PJL*(UJL*DZ+DTKTML*GAMBAL*DZODZL)+EDDYL*GAMBAL*DZODZL)   GIONEUT  834
     1    +(PJL*SNUWL*DELT/DZL)*DELT                                    GIONEUT  835
      GO TO 35                                                          GIONEUT  836
C                                                                       GIONEUT  837
C  COMPUTE LOWER BOUNDARY VALUES OF E AND F USING THE LOWER             GIONEUT  838
C  BOUNDARY CONDITIONS.                                                 GIONEUT  839
C                                                                       GIONEUT  840
   20 EJL=0.                                                            GIONEUT  841
      IF((I.EQ.8).OR.(I.EQ.13).OR.(I.EQ.15).OR.(I.EQ.21)) GO TO 30      GIONEUT  842
      IF((I.EQ. 22).OR.(I.EQ.23)) GO TO 30                              GIONEUT  843
      FJL=(NZERO(1)+DELT*FORM(1))/(1.0+DELT*REMV(1))                    GIONEUT  844
      GO TO 70                                                          GIONEUT  845
   30 FJL=N(1,I)                                                        GIONEUT  846
      GO TO 70                                                          GIONEUT  847
   35 IF(J .EQ. K) GO TO 50                                             GIONEUT  848
      DENOM=1.0/(BJ-CJ*EJL)                                             GIONEUT  849
      EJL=AJ*DENOM                                                      GIONEUT  850
      DJ=NZERO(J)+DELT*FORM(J)                                          GIONEUT  851
      FJL=(DJ+CJ*FJL)*DENOM                                             GIONEUT  852
      GO TO 70                                                          GIONEUT  853
C                                                                       GIONEUT  854
C  COMPUTE UPPER BOUNDARY VALUES OF E AND F USING THE UPPER             GIONEUT  855
C  BOUNDARY CONDITIONS.                                                 GIONEUT  856
C                                                                       GIONEUT  857
   50 DJ=NZERO(K)+DELT*FORM(K)                                          GIONEUT  858
   56 VEL(I)=0.                                                         GIONEUT  859
      IF((I.EQ.4).OR.(I.EQ.5).OR.(I.EQ.9)) GO TO 57                     GIONEUT  860
      IF(I .EQ. 11) GO TO 57                                            GIONEUT  861
      IF((I.GE.12).AND.(I.LE.15)) GO TO 57                              GIONEUT  862
      IF((I.EQ.10).OR.(I.EQ.19).OR.(I.EQ.20).OR.(I.EQ.22)) GO TO 57     GIONEUT  863
      IF((I.GE.27).AND.(I.LE.29)) GO TO 57                              GIONEUT  864
      CALL VELOCTY(I)                                                   GIONEUT  865
   57 IF(ICE .LT. 0) GO TO 65                                           GIONEUT  866
      IF(I .EQ. 11) GO TO 80                                            GIONEUT  867
      CALL COEFRE(I,K,SNU,NUM,OMEG)                                     GIONEUT  868
      SS=SNUW-VEL(I)*SNU                                                GIONEUT  869
      FJL=(DJ+CJ*FJL)/(BJ-AJ*(GAM+SS*(DELTAZ(K)*WGT/(BOLTZ*TEMP(K)))))  GIONEUT  870
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      SUBROUTINE EFORU(ICF)                                                 GIONEUT  757
C                                                                           GIONEUT  758
C  IF(IFC .GT. 0), COMPUTE THE E AND F ARRAYS.                              GIONEUT  759
C  IF(ICF .LT. 0), COMPUTE THE SPECIFIC VELOCITIES.                         GIONEUT  760
C                                                                           GIONEUT  761
      DIMENSION H(1)                                                        GIONEUT  762
C                                                                           GIONEUT  763
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)         GIONEUT  764
C                                                                           GIONEUT  765
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                      GIONEUT  766
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)        GIONEUT  767
C                                                                           GIONEUT  768
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,          GIONEUT  769
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                             GIONEUT  770
C                                                                           GIONEUT  771
      COMMON/TIMES/DAYS,DELT,TMAX                                           GIONEUT  772
C                                                                           GIONEUT  773
      COMMON/ALTITUD/ZBOT,ZTOP,TURB,TURBVAR                                 GIONEUT  774
C                                                                           GIONEUT  775
      COMMON/BOUNDRY/VEL(26)                                                GIONEUT  776
C                                                                           GIONEUT  777
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON              GIONEUT  778
C                                                                           GIONEUT  779
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)        GIONEUT  780
C                                                                           GIONEUT  781
      REAL N,NZERO,MASS                                                     GIONEUT  782
      EQUIVALENCE (U(1,21),H)                                               GIONEUT  783
C                                                                           GIONEUT  784
      I=ICF                                                                 GIONEUT  785
      IF(I .GT. 0) GO TO 1                                                  GIONEUT  786
      I=-I                                                                  GIONEUT  787
    1 WGT=MASS(I)                                                           GIONEUT  788
      GMOVK=GRAV*WGT/BOLTZ                                                  GIONEUT  789
      DTKOVM=DELT*BOLTZ/WGT                                                 GIONEUT  790
      DZ=1.5E+04                                                            GIONEUT  791
      DO 75 J=1,K                                                           GIONEUT  792
      ZE=Z(J)                                                               GIONEUT  793
      T=TEMP(J)                                                             GIONEUT  794
      DZL=DZ                                                                GIONEUT  795
      DZ=DELTAZ(J)                                                          GIONEUT  796
      DLNTDZ=DTEMDZ(J)                                                      GIONEUT  797
      IF(I .GT. 6) GO TO 6                                                  GIONEUT  798
      DLNTDZ=2.0*DLNTDZ                                                     GIONEUT  799
    6 GCRN=1.0/((1.0+ZE/RADIUS)**2)                                         GIONEUT  800
      DTKTML=DTKTM                                                          GIONEUT  801
      DTKTM=DTKOVM*T                                                        GIONEUT  802
      GAML=GAM                                                              GIONEUT  803
      GAM=1.0-(THERM(I)*DLNTDZ+GCRN*GMOVK/T)*DZ                             GIONEUT  804
      IF(I .GT. 6) GO TO 11                                                 GIONEUT  805
      GAM=GAM-H(J)*DZ                                                       GIONEUT  806
   11 PJL=PJ                                                                GIONEUT  807
      SNUWL=SNUW                                                            GIONEUT  808
      CALL COLFRE(I,J,SNU,SNUW,OMEG)                                        GIONEUT  809
      PJ=1.0/(1.0+SNU*OMEG*DELT)                                            GIONEUT  810
      UJL=UJ                                                                GIONEUT  811
      UJ=UZERO(J)                                                           GIONEUT  812
      IF(ICF .LT. 0) GO TO 60                                               GIONEUT  813
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      SUBROUTINE CO(J,RHO,NTOTAL,MBAR,VO)                                GIONEUT  724
C                                                                        GIONEUT  725
C  THIS SUBROUTINE COMPUTES THE TOTAL MASS DENSITY, RHO, THE TOTAL       GIONEUT  726
C  CONCENTRATION, NTOTAL, THE MEAN MOLECULAR WEIGHT, MBAR, AND THE       GIONEUT  727
C  MEAN MASS VELOCITY, VO, AT ALTITUDE WHERE THE INDEX IS J.             GIONEUT  728
C                                                                        GIONEUT  729
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)      GIONEUT  730
C                                                                        GIONEUT  731
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                   GIONEUT  732
     2       DE  (692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)     GIONEUT  733
C                                                                        GIONEUT  734
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,       GIONEUT  735
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                          GIONEUT  736
C                                                                        GIONEUT  737
      COMMON, NCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)     GIONEUT  738
C                                                                        GIONEUT  739
      REAL N,MBAR,NTOTAL,MASS                                            GIONEUT  740
C                                                                        GIONEUT  741
      RHO=0.                                                             GIONEUT  742
      NTOTAL=0.                                                          GIONEUT  743
      RHOC=0.                                                            GIONEUT  744
      DO 5 M=1,KSPECI                                                    GIONEUT  745
      EN=N(J,M)                                                          GIONEUT  746
      ENM=MASS(M)*EN                                                     GIONEUT  747
      RHO=RHO+ENM                                                        GIONEUT  748
      NTOTAL=NTOTAL+EN                                                   GIONEUT  749
      IF(M .EQ. 21) GO TO 5                                              GIONEUT  750
      RHOC=RHOC+ENM*U(J,M)                                               GIONEUT  751
    5 CONTINUE                                                           GIONEUT  752
      MBAR=RHO/NTOTAL                                                    GIONEUT  753
      VO=RHOC/RHO                                                        GIONEUT  754
      RETURN                                                             GIONEUT  755
      END                                                                GIONEUT  756
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      SUBROUTINE SMOOTH(A,N,M,B)                                        GIONEUT  675
C                                                                       GIONEUT  676
C  THIS SUBROUTINE SMOOTHS ARRAY A OF N POINTS WITH AN M POINT          GIONEUT  677
C  RUNNING MEAN.  THE SMOOTHED ARRAY IS STORED IN B.                    GIONEUT  678
C                                                                       GIONEUT  679
      DIMENSION A(1),B(1)                                               GIONEUT  680
C                                                                       GIONEUT  681
      IF(M .EQ. 0) GO TO 10                                             GIONEUT  682
      I=(M-1)/2                                                         GIONEUT  683
      K=N-M+1                                                           GIONEUT  684
      C=M                                                               GIONEUT  685
      DO 2 J=1,K                                                        GIONEUT  686
      S=0.                                                              GIONEUT  687
      JJ=J+M-1                                                          GIONEUT  688
      DO 1 L=J,JJ                                                       GIONEUT  689
1     S=S+A(L)                                                          GIONEUT  690
      JAY=J+I                                                           GIONEUT  691
2     B(JAY)=S/C                                                        GIONEUT  692
      I1=0                                                              GIONEUT  693
      K=M-2                                                             GIONEUT  694
3     C=K                                                               GIONEUT  695
      S=0.                                                              GIONEUT  696
      DO 4 J=1,K                                                        GIONEUT  697
4     S=S+A(J)                                                          GIONEUT  698
      JAY=I-I1                                                          GIONEUT  699
      B(JAY)=S/C                                                        GIONEUT  700
      K=K-2                                                             GIONEUT  701
      I1=I1+1                                                           GIONEUT  702
      IF(K .NE. 1) GO TO 3                                              GIONEUT  703
      I1=1                                                              GIONEUT  704
      K=N-M+3                                                           GIONEUT  705
      C=M-2                                                             GIONEUT  706
5     S=0.                                                              GIONEUT  707
      DO 6 J=K,N                                                        GIONEUT  708
6     S=S+A(J)                                                          GIONEUT  709
      JAY=N-I+I1                                                        GIONEUT  710
      B(JAY)=S/C                                                        GIONEUT  711
      K=K+2                                                             GIONEUT  712
      C=C-2.                                                            GIONEUT  713
      I1=I1+1                                                           GIONEUT  714
      IF(K .NE. N) GO TO 5                                              GIONEUT  715
      B(1)=A(1)                                                         GIONEUT  716
      B(N)=A(N)                                                         GIONEUT  717
      RETURN                                                            GIONEUT  718
10    DO 20 J=1,N                                                       GIONEUT  719
      B(J)=A(J)                                                         GIONEUT  720
20    CONTINUE                                                          GIONEUT  721
      RETURN                                                            GIONEUT  722
      END                                                               GIONEUT  723
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      RETURN                                                            GIONEUT  627
C                                                                       GIONEUT  628
C  ADJUST THE LARGEST NEGATIVE SPECIES CONCENTRATIONS TO                GIONEUT  629
C  INSURE CONSERVATION OF CHARGE.                                       GIONEUT  630
C                                                                       GIONEUT  631
C                                                                       GIONEUT  632
25    DO 50 J=1,K2                                                      GIONEUT  633
      SUMP=0.                                                           GIONEUT  634
      SUMM=0.                                                           GIONEUT  635
      DO 30 I=1,6                                                       GIONEUT  636
      SUMP=SUMP+N(J,I)                                                  GIONEUT  637
30    CONTINUE                                                          GIONEUT  638
      DO 35 I=28,29                                                     GIONEUT  639
      SUMP=SUMP+N(J,I)                                                  GIONEUT  640
35    CONTINUE                                                          GIONEUT  641
      DO 40 I=9,24                                                      GIONEUT  642
      SUMP=SUMP+CONC(J,I)                                               GIONEUT  643
40    CONTINUE                                                          GIONEUT  644
      BIG=N(J,30)                                                       GIONEUT  645
      JBIG=1                                                            GIONEUT  646
      DO 70 I=1,8                                                       GIONEUT  647
      IF(CONC(J,I) .LE. BIG) GO TO 70                                   GIONEUT  648
      BIG=CONC(J,I)                                                     GIONEUT  649
      JBIG=I+1                                                          GIONEUT  650
70    CONTINUE                                                          GIONEUT  651
      DO 75 I=1,9                                                       GIONEUT  652
      IF(I .EQ. JBIG) GO TO 75                                          GIONEUT  653
      IF(I .EQ. 1) SUMM=SUMM+N(J,30)                                    GIONEUT  654
      IF(I .NE. 1) SUMM=SUMM+CONC(J,I-1)                                GIONEUT  655
75    CONTINUE                                                          GIONEUT  656
      BAL=SUMP-SUMM                                                     GIONEUT  657
      IF(BAL .LT. 0.) STOP 7                                            GIONEUT  658
      IF(JBIG .EQ. 1) N(J,30)=BAL                                       GIONEUT  659
      IF(JBIG .NE. 1) CONC(J,JBIG-1)=BAL                                GIONEUT  660
50    CONTINUE                                                          GIONEUT  661
      KK=K2+1                                                           GIONEUT  662
      DO 65 J=KK,K                                                      GIONEUT  663
      SUMP=0.                                                           GIONEUT  664
      DO 55 I=1,6                                                       GIONEUT  665
      SUMP=SUMP+N(J,I)                                                  GIONEUT  666
55    CONTINUE                                                          GIONEUT  667
      DO 60 I=28,29                                                     GIONEUT  668
      SUMP=SUMP+N(J,I)                                                  GIONEUT  669
60    CONTINUE                                                          GIONEUT  670
      N(J,30)=SUMP                                                      GIONEUT  671
65    CONTINUE                                                          GIONEUT  672
      RETURN                                                            GIONEUT  673
      END                                                               GIONEUT  674
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      SUBROUTINE SMOOTHY(NUM,NSPEC)                                     GIONEUT  570
C                                                                       GIONEUT  571
C  THIS SUBROUTINE SMOOTHS SPECIFIED PROFILES WITH AN "IRUN" POINT      GIONEUT  572
C  RUNNING MEAN.                                                        GIONEUT  573
C                                                                       GIONEUT  574
      DIMENSION NSPEC(1),ZNEW(792),DENS(792),SMUTHN(1)                  GIONEUT  575
C                                                                       GIONEUT  576
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     GIONEUT  577
C                                                                       GIONEUT  578
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT  579
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT  580
C                                                                       GIONEUT  581
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT  582
     1       K2,KMIN1,ITURB,CXINCON,SCXI,NREAC2                         GIONEUT  583
C                                                                       GIONEUT  584
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)     GIONEUT  585
C                                                                       GIONEUT  586
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON          GIONEUT  587
C                                                                       GIONEUT  588
      REAL N,NZERO,MASS                                                 GIONEUT  589
C                                                                       GIONEUT  590
      EQUIVALENCE (NZERO,DENS),(FORM,SMUTHN)                            GIONEUT  591
      EQUIVALENCE (E,ZNEW)                                              GIONEUT  592
C                                                                       GIONEUT  593
      DATA IRUN/7/                                                      GIONEUT  594
C                                                                       GIONEUT  595
      IF(NUM .EQ. 0) RETURN                                             GIONEUT  596
C                                                                       GIONEUT  597
      GOVKT=(GRAV*(1.0/((1.0+400./RADIUS)**2)))/(BOLTZ*TEMP(K))         GIONEUT  598
      R=6.35107E+08                                                     GIONEUT  599
      DO 5 J=1,692                                                      GIONEUT  600
      ZNEW(J)=Z(J)                                                      GIONEUT  601
    5 CONTINUE                                                          GIONEUT  602
      DO 6 J=693,792                                                    GIONEUT  603
      ZNEW(J)=ZNEW(692)+FLOAT(J-692)                                    GIONEUT  604
    6 CONTINUE                                                          GIONEUT  605
      DO 15 I=1,NUM                                                     GIONEUT  606
      L=NSPEC(I)                                                        GIONEUT  607
      DO 7 J=1,692                                                      GIONEUT  608
      DENS(J)=N(J,L)                                                    GIONEUT  609
    7 CONTINUE                                                          GIONEUT  610
C                                                                       GIONEUT  611
C  EXTRAPOLATE THE CONCENTRAION OF SPECIES L TO 500 KM ASSUMING         GIONEUT  612
C  DIFFUSIVE EQUILIBRIUM ABOVE THE UPPER BOUNDARY.                      GIONEUT  613
C                                                                       GIONEUT  614
      DO 8 J=693,792                                                    GIONEUT  615
      DENS(J)=DENS(692)*EXP(-(GOVKT*MASS(L)*(ZNEW(J)-400.)*1.0E5)       GIONEUT  616
     1/(((400.*1.0E5/R)+1.0)*((ZNEW(J)*1.0E5/R)+1.0)))                 GIONEUT  617
    8 CONTINUE                                                          GIONEUT  618
      CALL SMOOTH(DENS,792,IRUN,SMUTHN)                                 GIONEUT  619
      DO 10 J=1,K                                                       GIONEUT  620
      N(J,L)=SMUTHN(J)                                                  GIONEUT  621
   10 CONTINUE                                                          GIONEUT  622
   15 CONTINUE                                                          GIONEUT  623
      DO 20 I=1,NUM                                                     GIONEUT  624
      IF(NSPEC(I) .LT. 7) GO TO 25                                      GIONEUT  625
   20 CONTINUE                                                          GIONEUT  626
```

```
  228   FORMAT(1H0,* DAY IS *,L1,5X,*NIGHT IS *,L1,5X,*DAY-NIGHT*,      GIONEUT  515
     1* TRANSITION HEIGHT IS *,F7.2)                                    GIONEUT  516
        IF(END) GO TO 270                                               GIONEUT  517
        CALL MOVLEV(U,OLDU,17992)                                       GIONEUT  518
        CALL MOVLEV(N,OLDN,20760)                                       GIONEUT  519
        CALL MOVLEV(CONC,OLDCON,11024)                                  GIONEUT  520
        CALL SECOND(T1)                                                 GIONEUT  521
        GO TO 1000                                                      GIONEUT  522
C                                                                       GIONEUT  523
C  ENTER HERE WHEN TIME IS RUNNING OUT OR SENSE SWITCH ONE IS ON.       GIONEUT  524
C                                                                       GIONEUT  525
  230   CXI=OLDCXI                                                      GIONEUT  526
        SCXI=CXI*DEGRAD                                                 GIONEUT  527
        TIME=TIME-DELT                                                  GIONEUT  528
        DELT=OLDELT                                                     GIONEUT  529
        ZTRANS=OLDZTR                                                   GIONEUT  530
        IF(PRINT) TIMOUT=TIMOUT-OPRINT                                  GIONEUT  531
        PRINT=.TRUE.                                                    GIONEUT  532
        END=.TRUE.                                                      GIONEUT  533
        LM=1                                                            GIONEUT  534
        GO TO 235                                                       GIONEUT  535
C                                                                       GIONEUT  536
C  ENTER HERE ON CALCULATION OF A NEGATIVE CONCENTRATION.               GIONEUT  537
C                                                                       GIONEUT  538
  245 KFAIL=2                                                           GIONEUT  539
        J=K                                                             GIONEUT  540
        GO TO 255                                                       GIONEUT  541
  250 KFAIL=3                                                           GIONEUT  542
        J=L                                                             GIONEUT  543
  255   WRITE(6,256)KFAIL,SYMBOL(I),Z(J),NEWN,N(J,I),TIME,DELT,SCXI,     GIONEUT  544
     1ITRATE                                                            GIONEUT  545
  256   FORMAT(I3,A10,0PF7.1,1P5E20.12,I5)                              GIONEUT  546
C                                                                       GIONEUT  547
C  ENTER HERE ON ERROR FROM SUBROUTINE CHEMION.                         GIONEUT  548
C                                                                       GIONEUT  549
  254   TIME=OLDTIME                                                    GIONEUT  550
        END=.FALSE.                                                     GIONEUT  551
        CXI=OLDCXI                                                      GIONEUT  552
        DELT=DELT*0.5                                                   GIONEUT  553
        IF(RESET) GO TO 257                                             GIONEUT  554
        IF(DELT .LT. 2.0**(-40)) 265,258                                GIONEUT  555
  257 RESET=.FALSE.                                                     GIONEUT  556
        TIMOUT=TIMOUT-OPRINT                                            GIONEUT  557
  258   LM=2                                                            GIONEUT  558
  235   NIGHT=LASTNT                                                    GIONEUT  559
        DAY=LASTDA                                                      GIONEUT  560
        CALL MOVLEV(OLDN,N,20760)                                       GIONEUT  561
        CALL MOVLEV(OLDCON,CONC,11024)                                  GIONEUT  562
        CALL MOVLEV(OLDU,U,17992)                                       GIONEUT  563
        IF(LM .EQ. 1) 162,1000                                          GIONEUT  564
  265 WRITE(6,345) TIME                                                 GIONEUT  565
  345 FORMAT(30H THE INCREMENT IS VANISHING AT1PE12.5,5H SEC.)           GIONEUT  566
        GO TO 230                                                       GIONEUT  567
  270 CONTINUE                                                          GIONEUT  568
        END                                                             GIONEUT  569
```

```
      WRITE(6,340)                                                      GIONEUT  458
340   FORMAT(1H1)                                                       GIONEUT  459
      WRITE(6,196) TIME,SCXI,IFRAME,IDAY,(OUTP(J),J=1,4)                GIONEUT  460
      WRITE(6,310)                                                      GIONEUT  461
310   FORMAT(*  ALT(KM) NO+/O2+ RATIO MEAN MOL WT  MASS DENSITY*,       GIONEUT  462
     1*    TOTAL NUMBER   MEAN MASS VEL       K-EDDY*)                 GIONEUT  463
      DO 325 J=1,K,12                                                   GIONEUT  464
      CALL CO(J,RHO,NTOTAL,MBAR,VMEAN)                                  GIONEUT  465
      MBAR=MBAR/ATCON                                                   GIONEUT  466
      RNOTO2=N(J,5)/N(J,4)                                              GIONEUT  467
      WRITE(6,330) Z(J),RNOTO2,MBAR,RHO,NTOTAL,VMEAN,DEDY(J)            GIONEUT  468
325   CONTINUE                                                          GIONEUT  469
      CALL CO(KMIN1,RHO,NTOTAL,MBAR,VMEAN)                              GIONEUT  470
      MBAR=MBAR/ATCON                                                   GIONEUT  471
      RNOTO2=N(KMIN1,5)/N(KMIN1,4)                                      GIONEUT  472
      WRITE(6,330) Z(KMIN1),RNOTO2,MBAR,RHO,NTOTAL,VMEAN,DEDY(KMIN1)    GIONEUT  473
      CALL CO(K,RHO,NTOTAL,MBAR,VMEAN)                                  GIONEUT  474
      MBAR=MBAR/ATCON                                                   GIONEUT  475
      RNOTO2=N(K,5)/N(K,4)                                              GIONEUT  476
      WRITE(6,330) Z(K),RNOTO2,MBAR,RHO,NTOTAL,VMEAN,DEDY(K)            GIONEUT  477
330   FORMAT(0PF8.2,1PE13.5,0PF10.3,4(3X,1PE13.5))                      GIONEUT  478
C                                                                       GIONEUT  479
C  PRINT LIST OF CHEMICAL REACTIONS WITH THE RATE OF EACH AT            GIONEUT  480
C  SELECTED ALTITUDES.                                                  GIONEUT  481
C                                                                       GIONEUT  482
      CALL CHEMPR(1)                                                    GIONEUT  483
      CALL CHEMPR(253)                                                  GIONEUT  484
      CALL CHEMPR(337)                                                  GIONEUT  485
      CALL CHEMPR(457)                                                  GIONEUT  486
      CALL CHEMPR(K)                                                    GIONEUT  487
160   DELT=AMIN1(2.0*DELT,TMAX)                                         GIONEUT  488
      IF(.NOT. PRINT) GO TO 161                                         GIONEUT  489
C                                                                       GIONEUT  490
C  WRITE INTERRUPT FILE ON TAPE 4.                                      GIONEUT  491
C                                                                       GIONEUT  492
      WRITE(4) TODAY,IFRAME,TIME,SCXI,CXI,DELT,TIMOUT                   GIONEUT  493
      DO 2224 L=1,KSPECI                                                GIONEUT  494
      WRITE(4) (U(J,L),J=1,K)                                           GIONEUT  495
2224  CONTINUE                                                          GIONEUT  496
      DO 280 L=1,ISPECI                                                 GIONEUT  497
      IF(L .GT. 30) GO TO 281                                           GIONEUT  498
      WRITE(4) (N(J,L),J=1,K)                                           GIONEUT  499
      GO TO 280                                                         GIONEUT  500
281   WRITE(4) (CONC(J,L-30),J=1,K2)                                    GIONEUT  501
280   CONTINUE                                                          GIONEUT  502
      ENDFILE 4                                                         GIONEUT  503
      CALL CLOCK(A1)                                                    GIONEUT  504
      WRITE(6,315) A1,IFRAME                                            GIONEUT  505
315   FORMAT(1H0,A10,* FRAME NO. *,I4,* HAS BEEN WRITTEN ON THE*,       GIONEUT  506
     1* INTERUPT TAPE.*)                                                GIONEUT  507
161   CALL HOUR(TIME,OUTP)                                              GIONEUT  508
      CALL CLOCK(A1)                                                    GIONEUT  509
      WRITE(6,227) A1,TIME,DELT,SCXI,ITRATE,(OUTP(J),J=1,4),DTIME       GIONEUT  510
227   FORMAT(1H0,A10,* TIME =*,1PE12.5,* SEC.  TIME INCREMENT =*,       GIONEUT  511
     1E12.5,*  CHI =*,0PF7.2,*  ITERATIONS =*,I4,*  HOUR =*,4A1,       GIONEUT  512
     2*  CP TIME =*,F10.2,* SEC.*)                                     GIONEUT  513
      WRITE(6,228) DAY,NIGHT,ZTRANS                                     GIONEUT  514
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     1*NUMBER   CHEMISTRY CHEMISTRY*,6X,*   ALT   NUMBER   *,                GIONEUT  401
     2*CHEMISTRY CHEMISTRY*)                                                 GIONEUT  402
201   FORMAT(*    KM   DENSITY  FORMATION REMOVAL*,8X,*    KM   *,          GIONEUT  403
     1*DENSITY  FORMATION REMOVAL*,8X,*    KM   DENSITY*,                    GIONEUT  404
     2*  FORMATION REMOVAL*)                                                 GIONEUT  405
      WRITE(6,200)                                                           GIONEUT  406
      WRITE(6,201)                                                           GIONEUT  407
      WRITE(6,202) (Z(J),CONC(J,I-3),E(J),H(J),Z(J),CONC(J,I-2),F(J),        GIONEUT  408
     1              UZERO(J),Z(J),CONC(J,I-1),FORM(J),REMV(J),J=1,K2,12)     GIONEUT  409
      WRITE(6,202) Z(K2),CONC(K2,I-3),E(K2),H(K2),Z(K2),CONC(K2,I-2),        GIONEUT  410
     1             F(K2),UZERO(K2),Z(K2),CONC(K2,I-1),FORM(K2),REMV(K2)      GIONEUT  411
202   FORMAT(3(0PF7.2,1P3E10.3,6X))                                          GIONEUT  412
210   CONTINUE                                                               GIONEUT  413
      I=25                                                                   GIONEUT  414
      DO 237 LL=1,2                                                          GIONEUT  415
      DO 211 J=1,K2                                                          GIONEUT  416
      CALL CHEM(I+30,J)                                                      GIONEUT  417
      REMV(J)=REMV(J)*CONC(J,I)                                              GIONEUT  418
211   CONTINUE                                                               GIONEUT  419
      IF(LL .EQ. 2) GO TO 240                                                GIONEUT  420
      DO 236 J=1,K2                                                          GIONEUT  421
      NZERO(J)=FORM(J)                                                       GIONEUT  422
      UZERO(J)=REMV(J)                                                       GIONEUT  423
236   CONTINUE                                                               GIONEUT  424
      I=I+1                                                                  GIONEUT  425
237   CONTINUE                                                               GIONEUT  426
240   DO 241 J=1,K2                                                          GIONEUT  427
      E(J)=0.                                                                GIONEUT  428
      F(J)=0.                                                                GIONEUT  429
      H(J)=0.                                                                GIONEUT  430
      DO 312 I=1,6                                                           GIONEUT  431
      E(J)=E(J)+N(J,I)                                                       GIONEUT  432
312   CONTINUE                                                               GIONEUT  433
      E(J)=E(J)+N(J,28)+N(J,29)                                              GIONEUT  434
      DO 313 I=9,24                                                          GIONEUT  435
      E(J)=E(J)+CONC(J,I)                                                    GIONEUT  436
313   CONTINUE                                                               GIONEUT  437
      DO 314 I=1,8                                                           GIONEUT  438
      F(J)=F(J)+CONC(J,I)                                                    GIONEUT  439
314   CONTINUE                                                               GIONEUT  440
      H(J)=F(J)/N(J,30)                                                      GIONEUT  441
241   CONTINUE                                                               GIONEUT  442
      WRITE(6,340)                                                           GIONEUT  443
      WRITE(6,196) TIME,SCXI,IFRAME,IDAY,(OUTP(J),J=1,4)                     GIONEUT  444
      WRITE(6,212) SYMBOL(55),SYMBOL(56)                                     GIONEUT  445
212   FORMAT(10X,A10,* PROFILE*,20X,A10,* PROFILE*)                          GIONEUT  446
      WRITE(6,213)                                                           GIONEUT  447
213   FORMAT(*   ALT   NUMBER   CHEMISTRY CHEMISTRY  ALT   NUMBER   *,      GIONEUT  448
     1*CHEMISTRY CHEMISTRY  TOTAL IONS  TOTAL IONS  LAMBDA*)                 GIONEUT  449
      WRITE(6,214)                                                           GIONEUT  450
214   FORMAT(*    KM   DENSITY  FORMATION REMOVAL    KM    DENSITY  *,      GIONEUT  451
     1*FORMATION REMOVAL    POSITIVE    NEGATIVE*)                          GIONEUT  452
      WRITE(6,215) (Z(J),CONC(J,25),NZERO(J),UZERO(J),Z(J),CONC(J,26),       GIONEUT  453
     1FORM(J),REMV(J),E(J),F(J),H(J),J=1,K2,12)                              GIONEUT  454
      WRITE(6,215) Z(K2),CONC(K2,25),NZERO(K2),UZERO(K2),Z(K2),              GIONEUT  455
     1CONC(K2,26),FORM(K2),REMV(K2),E(K2),F(K2),H(K2)                        GIONEUT  456
215   FORMAT(0PF7.2,1P3E10.3,0PF7.2,1P3E10.3,3E12.5)                         GIONEUT  457
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C                                                                       GIONEUT   287
C  COMPUTE EDDY DIFFUSION VELOCITIES.                                   GIONEUT   288
C                                                                       GIONEUT   289
      BIG=N(J+1,I)/EN                                                   GIONEUT   290
290   IF(EN .GT. 1.0E-10) GO TO 165                                     GIONEUT   291
      IF(BIG .GT. 100.) GO TO 170                                       GIONEUT   292
165   DED(J)=-(DEDY(J)/DELTAZ(J))*(BIG-1.0+GAMA*DELTAZ(J))              GIONEUT   293
170   CONTINUE                                                          GIONEUT   294
C                                                                       GIONEUT   295
C  COMPUTE FLUX GRADIENTS.                                              GIONEUT   296
C                                                                       GIONEUT   297
      DEDZ(1)=0.                                                        GIONEUT   298
      DFDZ(1)=0.                                                        GIONEUT   299
      DO 175 J=2,K                                                      GIONEUT   300
      DEDZ(J)=0.                                                        GIONEUT   301
      DFDZ(J)=(N(J,I)*U(J,I)-N(J-1,I)*U(J-1,I))/DELTAZ(J)               GIONEUT   302
      IF(J .GT. ITURB) GO TO 175                                        GIONEUT   303
      DEDZ(J)=(N(J,I)*DED(J)-N(J-1,I)*DED(J-1))/DELTAZ(J)               GIONEUT   304
175   CONTINUE                                                          GIONEUT   305
C                                                                       GIONEUT   306
C  COMPUTE CHEMISTRY PROFILES.                                          GIONEUT   307
C                                                                       GIONEUT   308
      DO 180 J=1,K                                                      GIONEUT   309
      CALL CHEM(I,J)                                                    GIONEUT   310
      REMV(J)=REMV(J)*N(J,I)                                            GIONEUT   311
180   CONTINUE                                                          GIONEUT   312
C                                                                       GIONEUT   313
C  COMPUTE THE TOTAL FLUX FOR EACH SPECIES.                             GIONEUT   314
C                                                                       GIONEUT   315
      DO 181 J=1,K                                                      GIONEUT   316
      PHI(J)=(U(J,I)+DED(J))*N(J,I)                                     GIONEUT   317
181   CONTINUE                                                          GIONEUT   318
      CALL HOUR(TIME,OUTP)                                              GIONEUT   319
      WRITE(6,335) SYMBOL(I)                                            GIONEUT   320
335   FORMAT(1H1,60X,A10,* PROFILE*)                                    GIONEUT   321
      WRITE(6,390) TIME,DELT,SCXI,ITER(I),IFRAME,IDAY,(OUTP(J),J=1,4)   GIONEUT   322
390   FORMAT(1H ,* TIME =*,1PE12.5,* SEC.  TIME INCREMENT =*,E12.5,     GIONEUT   323
     1*  CHI =*,0PF7.2,* DEGREES  ITERATIONS =*,I3,*  FRAME*,           GIONEUT   324
     2I4,*  DAY *,I3,* HOUR *,4A1)                                      GIONEUT   325
      WRITE(6,295)                                                      GIONEUT   326
295   FORMAT(*  ALT       NUMBER       SPECIFIC     SPECIFIC*,         GIONEUT   327
     1*     TURBULENT    TURBULENT    CHEMISTRY    CHEMISTRY*,         GIONEUT   328
     2*       TOTAL       DIFFUSION*)                                  GIONEUT   329
      WRITE(6,300)                                                      GIONEUT   330
300   FORMAT(*  KM        DENSITY      VELOCITY     GRADIENT     VELOCITY* GIONEUT   331
     1,*     GRADIENT     FORMATION      REMOVAL       FLUX*,          GIONEUT   332
     2*         VELOCITY*)                                             GIONEUT   333
      WRITE(6,320) (Z(J),N(J,I),U(J,I),DFDZ(J),DED(J),DEDZ(J),FORM(J),  GIONEUT   334
     1REMV(J),PHI(J),VBAR(J),J=1,K,12)                                  GIONEUT   335
320   FORMAT(0PF8.2,1PE13.5)                                            GIONEUT   336
      WRITE(6,320) Z(K),N(K,I),U(K,I),DFDZ(K),DED(K),DEDZ(K),FORM(K),   GIONEUT   337
     1REMV(K),PHI(K),VBAR(K)                                            GIONEUT   338
195   CONTINUE                                                          GIONEUT   339
      L=1                                                               GIONEUT   340
      DO 194 I=27,30                                                    GIONEUT   341
      DO 191 J=1,K                                                      GIONEUT   342
      CALL CHEM(I,J)                                                    GIONEUT   343
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      IF(ITMAX .EQ. 1) GO TO 139                                        GIONEUT  230
230   IF(ITRATE.EQ.1) GOTO 130                                          GIONEUT  231
C                                                                       GIONEUT  232
C  DETERMINE WHICH SPECIES REQUIRE FURTHER ITERATION.                   GIONEUT  233
C                                                                       GIONEUT  234
      BIG=0.                                                            GIONEUT  235
235   DO 120 I=1,KSPECI                                                 GIONEUT  236
      IF(IWHICH(I).EQ.0) GOTO 120                                       GIONEUT  237
      IF(BIGEST(I) .GT. ERSPECI) GO TO 117                              GIONEUT  238
      IWHICH(I)=0                                                       GIONEUT  239
      ITER(I)=ITRATE                                                    GIONEUT  240
240   IF(BIGEST(I) .LT. BIG) GO TO 120                                  GIONEUT  241
      BIG=BIGEST(I)                                                     GIONEUT  242
      IBIG=I                                                            GIONEUT  243
  120 CONTINUE                                                          GIONEUT  244
C                                                                       GIONEUT  245
245   ERS=ERRMAX                                                        GIONEUT  246
      IF(IBIG .EQ. 10) ERS=0.5                                          GIONEUT  247
      IF(BIG .LE. ERS) GO TO 139                                        GIONEUT  248
  130 CONTINUE                                                          GIONEUT  249
139   DO 135 I=1,KSPECI                                                 GIONEUT  250
250   IF(IWHICH(I) .EQ. 0) GO TO 135                                    GIONEUT  251
      ITER(I)=ITRATE                                                    GIONEUT  252
135   CONTINUE                                                          GIONEUT  253
      CALL SECOND(T2)                                                   GIONEUT  254
      DTIME=T2-T1                                                       GIONEUT  255
255   C                                                                 GIONEUT  256
C  IF THIS IS A PRINT STEP, COMPUTE FLUXES AND FLUX GRADIENTS FOR OUTPUT GIONEUT  257
C                                                                       GIONEUT  258
      IF(PRINT) GO TO 162                                               GIONEUT  259
      IF(TIME .LT. (DAYS*8.64E+04)) GO TO 160                           GIONEUT  260
260   END=.TRUE.                                                        GIONEUT  261
162   IDAY=((TIME+4.32E+04)/8.65E+04)+1                                 GIONEUT  262
      IFRAME=IFRAME+1                                                   GIONEUT  263
      DO 163 J=1,K                                                      GIONEUT  264
      CALL RATECN(J)                                                    GIONEUT  265
265   CALL MOVLEV(DK(128),RATES(1,J),88)                                GIONEUT  266
163   CONTINUE                                                          GIONEUT  267
C                                                                       GIONEUT  268
C  COMPUTE MOLECULAR AND EDDY DIFFUSION FLUXES.                         GIONEUT  269
C                                                                       GIONEUT  270
270   DO 195 I=1,KSPECI                                                 GIONEUT  271
      IF(I .EQ. 21) GO TO 195                                           GIONEUT  272
      DO 170 J=1,K                                                      GIONEUT  273
C                                                                       GIONEUT  274
C  COMPUTE MOLECULAR DIFFUSION VELOCITIES.                              GIONEUT  275
275   C                                                                 GIONEUT  276
      CALL CO(J,RHO,NTOTAL,MBAR,VMEAN)                                  GIONEUT  277
      VBAR(J)=0.                                                        GIONEUT  278
      EN=N(J,I)                                                         GIONEUT  279
      DED(J)=0.                                                         GIONEUT  280
280   IF(EN .EQ. 0.) GO TO 170                                          GIONEUT  281
      VBAR(J)=U(J,I)-VMEAN                                              GIONEUT  282
      IF(J .GT. ITURB) GO TO 170                                        GIONEUT  283
      T=TEMP(J)                                                         GIONEUT  284
      ZZ=Z(J)                                                           GIONEUT  285
285   GAMA=DIFMOL(J)*(GRA*GRAVCOR(ZZ)*MBAR)/(BOLTZ*T)                   GIONEUT  286
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      CALL EFORU(I)                                                    GIONEUT  172
C                                                                      GIONEUT  174
C  COMPUTE HEIGHT PROFILES AT (T+DELTA T) USING THE RECURSION          GIONEUT  175
C  RELATION N(J)=N(J+1)*E(J)+F(J).                                     GIONEUT  176
C                                                                      GIONEUT  177
      NEWN=F(K)                                                        GIONEUT  178
C                                                                      GIONEUT  179
      IF(NEWN .GT. 0.) GO TO 10                                        GIONEUT  180
      IF(N(K,I) .GT. 1.0E-02) GO TO 245                                GIONEUT  181
      NEWN=N(K,I)                                                      GIONEUT  182
10    IF(ITRATE .EQ. 1) GO TO 70                                       GIONEUT  183
      IF(NEWN .LT. 1.0) GO TO 70                                       GIONEUT  184
      RELER=ABS(NEWN-N(K,I))/NEWN                                      GIONEUT  185
      BIGEST(I)=RELER                                                  GIONEUT  186
70    N(K,I)=NEWN                                                      GIONEUT  187
      DO 100 J=1,KMIN1                                                 GIONEUT  188
      L=K-J                                                            GIONEUT  189
      NEWN=E(L)*N(L+1,I)+F(L)                                          GIONEUT  190
      IF(NEWN .GT. 0.) GO TO 11                                        GIONEUT  191
      IF(N(L,I) .GT. 1.0E-02) GO TO 250                                GIONEUT  192
      NEWN=N(L,I)                                                      GIONEUT  193
11    IF(ITRATE .EQ. 1) GO TO 95                                       GIONEUT  194
      IF(NEWN .LT. 1.0) GO TO 95                                       GIONEUT  195
      RELER=ABS(NEWN-N(L,I))/NEWN                                      GIONEUT  196
      IF(BIGEST(I) .LT. RELER) BIGEST(I)=RELER                         GIONEUT  197
95    N(L,I)=NEWN                                                      GIONEUT  198
  100 CONTINUE                                                         GIONEUT  199
  105 CONTINUE                                                         GIONEUT  200
C                                                                      GIONEUT  201
C  COMPUTE THOSE SPECIES TO BE DETERMINED FROM CHEMISTRY ONLY.         GIONEUT  202
C                                                                      GIONEUT  203
      CALL CHEMION                                                     GIONEUT  204
C                                                                      GIONEUT  205
      IF(END) GO TO 254                                                GIONEUT  206
C                                                                      GIONEUT  207
C  GO GET THE VELOCITIES FOR SPECIES IN THE TRANSPORT MODE.            GIONEUT  208
C                                                                      GIONEUT  209
      DO 110 I=1,KSPECI                                                GIONEUT  210
      IF(I .EQ. 21) GO TO 110                                          GIONEUT  211
      CALL MOVLEV(OLDU(1,I),UZERO,K)                                   GIONEUT  212
      CALL CHEM(I,KMIN1)                                               GIONEUT  213
      CALL CHEM(I,K)                                                   GIONEUT  214
      IF(I .NE. 1) GO TO 108                                           GIONEUT  215
      DO 107 J=2,K                                                     GIONEUT  216
      H(J)=(1.0-(N(J-1,30)/N(J,30)))/DELTAZ(J-1)                       GIONEUT  217
107   CONTINUE                                                         GIONEUT  218
      H(1)=H(2)                                                        GIONEUT  219
108   CALL EFORU(-I)                                                   GIONEUT  220
C                                                                      GIONEUT  221
C  TEST FOR TERMINATION OF CALCULATIONS.                               GIONEUT  222
C                                                                      GIONEUT  223
      CALL SSWTCH(NSWTCH,NSTATUS)                                      GIONEUT  224
      IF(NSTATUS.NE.2) GOTO 230                                        GIONEUT  225
      CALL SECOND(TA)                                                  GIONEUT  226
      IF((TYME-TA).LT.TOFF) GOTO 230                                   GIONEUT  227
230   CONTINUE                                                         GIONEUT  228
C                                                                      GIONEUT  229
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      DO 625 J=1,59                                                     GIONEUT  116
      WRITE(6,610) (DIS(15,J),(DIS(LL,J),LL=7,14))                      GIONEUT  117
625   CONTINUE                                                          GIONEUT  118
      LOOK FA SE.                                                       GIONEUT  119
24    IF(ITRATE .NE. 1) GO TO 6                                         GIONEUT  120
      IF(I .NE. 1) GO TO 6                                              GIONEUT  121
      IF(NUM .EQ. 0) GO TO 6                                            GIONEUT  122
      CALL SMOOTHY(NUM,NSPEC)                                           GIONEUT  123
      WRITE(6,2)                                                        GIONEUT  124
2     FORMAT(1HO,'  THE FOLLOWING SPECIES PROFILES HAVE BEEN',          GIONEUT  125
     1' SMOOTHED.')                                                     GIONEUT  126
      DO 4 II=1,NUM                                                     GIONEUT  127
      L=NSPEC(II)                                                       GIONEUT  128
      WRITE(6,3) SYMBOL(L)                                              GIONEUT  129
3     FORMAT(10X,A10)                                                   GIONEUT  130
4     CONTINUE                                                          GIONEUT  131
C                                                                       GIONEUT  132
C  RECOMPUTE THE VELOCITY PROFILES FOR THOSE SPECIES WHOSE              GIONEUT  133
C  CONCENTRATION PROFILES HAVE BEEN SMOOTHED.                           GIONEUT  134
C                                                                       GIONEUT  135
      IP=0                                                              GIONEUT  136
      DO 29 IM=1,NUM                                                    GIONEUT  137
      II=NSPEC(IM)                                                      GIONEUT  138
40    IP=IP+1                                                           GIONEUT  139
      IF(IP .NE. II) GO TO 40                                           GIONEUT  140
      CALL MOVLEV(OLDU(1,II),UZERO,K)                                   GIONEUT  141
      CALL CHEM(II,KMIN1)                                               GIONEUT  142
      CALL CHEM(II,K)                                                   GIONEUT  143
      IF(IM .NE. 1) GO TO 28                                            GIONEUT  144
      DO 27 J=2,K                                                       GIONEUT  145
      H(J)=(1.0-(N(J-1,30)/N(J,30)))/DELTAZ(J-1)                        GIONEUT  146
27    CONTINUE                                                          GIONEUT  147
      H(1)=H(2)                                                         GIONEUT  148
28    CALL EFORU(-II)                                                   GIONEUT  149
29    CONTINUE                                                          GIONEUT  150
      CALL MOVLEV(U,OLDU,17992)                                         GIONEUT  151
      CALL MOVLEV(N,OLDN,20760)                                         GIONEUT  152
      CALL MOVLEV(CONC,OLDCON,11024)                                    GIONEUT  153
6     IF(IWHICH(1) .EQ. 0) GO TO 105                                    GIONEUT  154
      CALL MOVLEV(OLDN(1,I),NZERO,K)                                    GIONEUT  155
      CALL MOVLEV(OLDU(1,I),UZERO,K)                                    GIONEUT  156
C                                                                       GIONEUT  157
C  GO GET CHEMISTRY FORMATION AND REMOVAL RATES FOR SPECIES I.          GIONEUT  158
C                                                                       GIONEUT  159
      DO 30 J=1,K                                                       GIONEUT  160
      CALL CHEM(I,J)                                                    GIONEUT  161
C                                                                       GIONEUT  162
C  TEST FOR TERMINATION OF CALCULATIONS.                                GIONEUT  163
C                                                                       GIONEUT  164
      CALL SSWTCH(NSWTCH,NSTATUS)                                       GIONEUT  165
      IF(NSTATUS .NE. 2) GO TO 230                                      GIONEUT  166
      CALL SECOND(TUSED)                                                GIONEUT  167
      IF((TYMS-TUSED) .LT. TOFF) GO TO 230                              GIONEUT  168
30    CONTINUE                                                          GIONEUT  169
C                                                                       GIONEUT  170
C  GO GET E AND F ARRAYS.                                               GIONEUT  171
C                                                                       GIONEUT  172
```

```
                                                                        GIONEUT   54
                                                                        GIONEUT   55
                                                                        GIONEUT   61
                                                                        GIONEUT   62
                                                                        GIONEUT   63
                                                                        GIONEUT   64
                                                                        GIONEUT   65
      OLDZTR=ZTRANS                                                     GIONEUT   66
      LASTNT=NIGHT                                                      GIONEUT   67
      LASTDA=DAY                                                        GIONEUT   68
      CALL TIMER                                                        GIONEUT   69
      OLDELT=DELT                                                       GIONEUT   70
      IF(.NOT. DAY .OR. NIGHT) JLOOK=.TRUE.                             GIONEUT   71
      IF(NIGHT) JLOOK=.FALSE.                                           GIONEUT   72
      SCXI=CXI*DEGRAD                                                   GIONEUT   73
      DO 20 I=1,KSPECI                                                  GIONEUT   74
      IWHICH(I)=1                                                       GIONEUT   75
      ITER(I)=999                                                       GIONEUT   76
   20 CONTINUE                                                          GIONEUT   77
      IWHICH(21)=0                                                      GIONEUT   78
C                                                                       GIONEUT   79
C  BEGINNING OF ITERATION LOOP.                                         GIONEUT   80
C                                                                       GIONEUT   81
      DO 130 ITRATE=1,ITMAX                                             GIONEUT   82
      DO 105 I=1,KSPECI                                                 GIONEUT   83
      BIGEST(I)=0.                                                      GIONEUT   84
      IF(I .NE. 1) GO TO 24                                             GIONEUT   85
      DO 22 J=2,K                                                       GIONEUT   86
      H(J)=(1.0-(N(J-1,30)/N(J,30)))/DELTAZ(J-1)                        GIONEUT   87
22    CONTINUE                                                          GIONEUT   88
      H(1)=H(2)                                                         GIONEUT   89
C                                                                       GIONEUT   90
C  TEST FOR TERMINATION OF CALCULATIONS.                                GIONEUT   91
C                                                                       GIONEUT   92
      CALL SSWTCH(NSWTCH,NSTATUS)                                       GIONEUT   93
      IF(NSTATUS .NE. 2) GO TO 230                                      GIONEUT   94
      CALL SECOND(TUSED)                                                GIONEUT   95
      IF((TYME-TUSED) .LT. TOFF) GO TO 230                              GIONEUT   96
      DO 21 J=1,K                                                       GIONEUT   97
      CALL RATECN(J)                                                    GIONEUT   98
      CALL MOVLEV(DK(128),RATES(1,J),88)                                GIONEUT   99
21    CONTINUE                                                          GIONEUT  100
      IF(.NOT. JLOOK) GO TO 24                                          GIONEUT  101
      WRITE(6,600) SCXI                                                 GIONEUT  102
600   FORMAT(1H1,10X,* CHI =*,F7.2,* DEGREES.*)                         GIONEUT  103
      WRITE(6,605)                                                      GIONEUT  104
605   FORMAT(1H0,*   ALT (KM)  O2 DENSITY  O2 COLUMN   O3 DENSITY*,     GIONEUT  105
     1*  O3 COLUMN    JO2 K192    JO2 K193    JO3 K194    *,           GIONEUT  106
     2*JO3 K195    JH2O K196  JH2O2 K197*)                             GIONEUT  107
      DO 615 J=1,59                                                     GIONEUT  108
      WRITE(6,610) ((DIS(LL,J),LL=15,19),(DIS(LL,J),LL=1,6))            GIONEUT  109
610   FORMAT(0PF10.2,2X,1P10E12.5)                                      GIONEUT  110
615   CONTINUE                                                          GIONEUT  111
      WRITE(6,600) SCXI                                                 GIONEUT  112
      WRITE(6,620)                                                      GIONEUT  113
620   FORMAT(1H0,*   ALT (KM)   JHO2 K198   JNO K199    JNO2 K200*,     GIONEUT  114
     1*   JNO3 K201  JHNO2 K202   JCO2 K203   JCO2 K204   JNO3 K205*)   GIONEUT  115
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     1     -CJ*EJL)                                                          GIONEUT  871
           EJL=0.                                                            GIONEUT  872
           GO TO 70                                                          GIONEUT  873
80         FJL=(NZERO(K)+FORM(K)*DELT)/(1.0+REMV(K)*DELT)                   GIONEUT  874
           EJL=0.                                                            GIONEUT  875
           GO TO 70                                                          GIONEUT  876
C                                                                            GIONEUT  877
C  COMPUTE THE SPECIFIC VELOCITY ARRAY FOR SPECIES ICF.                      GIONEUT  878
C                                                                            GIONEUT  879
60         IF(J .EQ. K) GO TO 56                                             GIONEUT  880
           AJ=N(J+1,I)/N(J,I)                                                GIONEUT  881
           IF(N(J,I) .GT. 1.0E-10) GO TO 61                                  GIONEUT  882
           IF(AJ .LT. 100.) GO TO 61                                         GIONEUT  883
           U(J,I)=0.                                                         GIONEUT  884
           GO TO 75                                                          GIONEUT  885
61         U(J,I)=PJ*(UJ-(DTKTM/DZ)*(AJ-GAM)+DELT*SNUW)                      GIONEUT  886
           GO TO 75                                                          GIONEUT  887
65         U(K,I)=VEL(I)                                                     GIONEUT  888
           GO TO 75                                                          GIONEUT  889
70         E(J)=EJL                                                          GIONEUT  890
           F(J)=FJL                                                          GIONEUT  891
75         CONTINUE                                                          GIONEUT  892
           RETURN                                                            GIONEUT  893
           END                                                               GIONEUT  894
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      SUBROUTINE COLFRE(I,J,SNU,SNUW,OMEG)                              GIONEUT   895
C                                                                       GIONEUT   896
C  THIS SUBROUTINE COMPUTES THE SUM OF THE COLLISION FREQUENCIES        GIONEUT   897
C  AND THE SUM OF THE COLLISION FREQUENCIES TIMES THE VELOCITIES.       GIONEUT   898
C  SEE BANKS AND KOCHARTS, "AERONOMY", CHAPTER 9.                       GIONEUT   899
C                                                                       GIONEUT   900
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     GIONEUT   901
C                                                                       GIONEUT   902
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT   903
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT   904
C                                                                       GIONEUT   905
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT   906
     1       K2,KMIN1,ITURB,CXINCON,SCXI,NREAC2                         GIONEUT   907
C                                                                       GIONEUT   908
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)     GIONEUT   909
C                                                                       GIONEUT   910
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON          GIONEUT   911
C                                                                       GIONEUT   912
      COMMON/COLFRE/D(26,26)                                            GIONEUT   913
C                                                                       GIONEUT   914
      REAL N,MASS                                                       GIONEUT   915
C                                                                       GIONEUT   916
      DATA GAUS/0.25/,CHARG/4.803E-10/                                  GIONEUT   917
C                                                                       GIONEUT   918
      SNU =0.                                                           GIONEUT   919
      SNUW=0.                                                           GIONEUT   920
      OMEG=1.0                                                          GIONEUT   921
      AMUI=ATWT(I)                                                      GIONEUT   922
      T=TEMP(J)                                                         GIONEUT   923
      ST=SQRT(T)                                                        GIONEUT   924
      T1=1.0/(T**1.5)                                                   GIONEUT   925
      T2=300.0/T                                                        GIONEUT   926
      TS=SQRT(2.0*T)                                                    GIONEUT   927
      DO 50 L=1,KSPECI                                                  GIONEUT   928
      AMUL=ATWT(L)                                                      GIONEUT   929
      RMAS=1.0/(SQRT((AMUI*AMUL)/(AMUI+AMUL)))                          GIONEUT   930
      IF(I .LE. 6) GO TO 15                                             GIONEUT   931
      IF(L .LE. 6) GO TO 25                                             GIONEUT   932
C                                                                       GIONEUT   933
C  COMPUTE NEUTRAL-NEUTRAL COLLISION FREQUENCIES.                       GIONEUT   934
C                                                                       GIONEUT   935
      ANU=N(J,L)*D(I,L)*ST                                              GIONEUT   936
      SNU=SNU+ANU                                                       GIONEUT   937
      IF(L .EQ. 21) GO TO 50                                            GIONEUT   938
      SNUW=SNUW+ANU*U(J,L)                                              GIONEUT   939
      GO TO 50                                                          GIONEUT   940
15    IF(L .GT. 6) GO TO 24                                             GIONEUT   941
C                                                                       GIONEUT   942
C  COMPUTE ION-ION COLLISION FREQUENCIES.                               GIONEUT   943
C                                                                       GIONEUT   944
      ANU=1.3*N(J,L)*RMAS*T1                                            GIONEUT   945
      GO TO 26                                                          GIONEUT   946
C                                                                       GIONEUT   947
C  COMPUTE ION-NEUTRAL COLLISION FREQUENCIES.                           GIONEUT   948
C                                                                       GIONEUT   949
25    II=I                                                              GIONEUT   950
      GO TO 27                                                          GIONEUT   951
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   24    II=L                                                              GIONEUT  952
   27    ALF=POLAR(II)                                                     GIONEUT  953
60       IF(ALF .EQ. 0.) GO TO 50                                          GIONEUT  954
C                                                                          GIONEUT  955
C  AVERAGE ION-NEUTRAL COLLISION FREQUENCY FOR MOMENTUM TRANSFER.          GIONEUT  956
C  BANKS AND KOCHARTS, EQUATION 9.73.                                      GIONEUT  957
C                                                                          GIONEUT  958
65       ANU=2.6E-09*N(J,L)*SQRT(ALF)*RMAS                                 GIONEUT  959
         IF(((I.EQ.1).AND.(L.EQ.7 )).OR.((I.EQ.7 ).AND.(L.EQ.1))) GO TO 1  GIONEUT  960
         IF(((I.EQ.1).AND.(L.EQ.11)).OR.((I.EQ.11).AND.(L.EQ.1))) GO TO 11 GIONEUT  961
         IF(((I.EQ.2).AND.(L.EQ.8 )).OR.((I.EQ.8 ).AND.(L.EQ.2))) GO TO 2  GIONEUT  962
         IF(((I.EQ.2).AND.(L.EQ.21)).OR.((I.EQ.21).AND.(L.EQ.2))) GO TO 21 GIONEUT  963
70       IF(((I.EQ.2).AND.(L.EQ.23)).OR.((I.EQ.23).AND.(L.EQ.2))) GO TO 3  GIONEUT  964
         IF(((I.EQ.3).AND.(L.EQ.7 )).OR.((I.EQ.7 ).AND.(L.EQ.3))) GO TO 31 GIONEUT  965
         IF(((I.EQ.3).AND.(L.EQ.8 )).OR.((I.EQ.8 ).AND.(L.EQ.3))) GO TO 4  GIONEUT  966
         IF(((I.EQ.3).AND.(L.EQ.11)).OR.((I.EQ.11).AND.(L.EQ.3))) GO TO 5  GIONEUT  967
         IF(((I.EQ.4).AND.(L.EQ.18)).OR.((I.EQ.18).AND.(L.EQ.4))) GO TO 6  GIONEUT  968
75       IF(((I.EQ.4).AND.(L.EQ.8 )).OR.((I.EQ.8 ).AND.(L.EQ.4))) GO TO 61 GIONEUT  969
         IF(((I.EQ.6).AND.(L.EQ.8 )).OR.((I.EQ.8 ).AND.(L.EQ.6))) GO TO 7  GIONEUT  970
         IF(((I.EQ.6).AND.(L.EQ.16)).OR.((I.EQ.16).AND.(L.EQ.6))) GO TO 71 GIONEUT  971
   26    BNU=ANU*(AMUL/(AMUI+AMUL))                                        GIONEUT  972
         SNU =SNU+BNU                                                      GIONEUT  973
80       IF(I .EQ. L) GO TO 50                                             GIONEUT  974
         IF(L .EQ. 21) GO TO 50                                            GIONEUT  975
         SNUW=SNUW+BNU*U(J,L)                                              GIONEUT  976
         GO TO 50                                                          GIONEUT  977
C                                                                          GIONEUT  978
85       C  AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION H+ - O.  GIONEUT  979
C                                                                          GIONEUT  980
    1    ENG=3.8E-10*N(J,L)                                                GIONEUT
         GO TO 8                                                           GIONEUT  982
C                                                                          GIONEUT  983
90       C  AVERAGE REDUCED CHARGE EXCHANGE COLLISION FREQUENCY FOR H+ - H.  GIONEUT  984
C                                                                          GIONEUT  985
   11    ANU=ANU+1.0E-10*T3*N(J,L)                                         GIONEUT  986
         GO TO 26                                                          GIONEUT  987
C                                                                          GIONEUT  988
95       C  AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION HE+ + O2.  GIONEUT  989
C                                                                          GIONEUT  990
    2    ENG=2.0E-10*N(J,L)                                                GIONEUT  991
         GO TO 8                                                           GIONEUT  992
C                                                                          GIONEUT  993
100      C  AVERAGE REDUCED CHARGE EXCHANGE COLLISION FREQUENCY FOR HE+ + HE.  GIONEUT  994
C                                                                          GIONEUT  995
   21    ANU=ANU+3.0E-11*T3*N(J,L)                                         GIONEUT  996
         GO TO 26                                                          GIONEUT  997
C                                                                          GIONEUT  998
105      C  AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION HE+ + N2.  GIONEUT  999
    3    ENG=3.5E-10*N(J,L)                                                GIONEUT 1000
         GO TO 8                                                           GIONEUT 1001
C                                                                          GIONEUT 1002
C  AVERAGE REDUCED CHARGE EXCHANGE COLLISION FREQUENCY FOR O+ + O.         GIONEUT 1003
110    C                                                                   GIONEUT 1004
   31    ANU=ANU+1.6E-11*T3*N(J,L)                                         GIONEUT 1005
         GO TO 26                                                          GIONEUT 1006
C                                                                          GIONEUT 1007
C  AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REATION O+ + O2.         GIONEUT 1008
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      C                                                                  GIONEUT  1009
      4     ENG=2.0E-11*(T2**0.4)*N(J,L)                                 GIONEUT  1010
            GO TO 8                                                      GIONEUT  1011
      C                                                                  GIONEUT  1012
      C  AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION O+ + H. GIONEUT  1013
      C                                                                  GIONEUT  1014
      5     ENG=6.8E-10*N(J,L)                                           GIONEUT  1015
            GO TO 8                                                      GIONEUT  1016
      C                                                                  GIONEUT  1017
      C  AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION O2+ + NO. GIONEUT  1018
      C                                                                  GIONEUT  1019
      6     ENG=4.4E-10*N(J,L)                                           GIONEUT  1020
            GO TO 8                                                      GIONEUT  1021
      C                                                                  GIONEUT  1022
      C  AVERAGE REDUCED CHARGE EXCHANGE COLLISION FREQUENCY FOR O2+ + O2. GIONEUT  1023
      C                                                                  GIONEUT  1024
      61    ANU=ANU+1.1E-11*T3*N(J,L)                                    GIONEUT  1025
            GO TO 26                                                     GIONEUT  1026
      C                                                                  GIONEUT  1027
      C  AVERAGE REDUCED CHARGE EXCHANGE COLLISION FREQUENCY FOR N+ + N. GIONEUT  1028
      C                                                                  GIONEUT  1029
      71    ANU=ANU+1.7E-11*T3*N(J,L)                                    GIONEUT  1030
            GO TO 26                                                     GIONEUT  1031
      C                                                                  GIONEUT  1032
      C  AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION N+ + O2. GIONEUT  1033
      C                                                                  GIONEUT  1034
      7     ENG=5.5E-10*(T2**0.17)*2.0*N(J,L)                            GIONEUT  1035
      8     ANU=ANU+1.73725*ENG                                          GIONEUT  1036
            GO TO 26                                                     GIONEUT  1037
      50    CONTINUE                                                     GIONEUT  1038
            IF(I .GT. 6) RETURN                                          GIONEUT  1039
            G1=((GAUS*CHARG)/(MASS(I)*3.0E10))**2                        GIONEUT  1040
            G2=SNU**2                                                    GIONEUT  1041
            OMEG=(G1+G2)/(G1*SIN2I+G2)                                   GIONEUT  1042
            RETURN                                                       GIONEUT  1043
            END                                                          GIONEUT  1044
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      SUBROUTINE VELOCTY(I)                                              GIONEUT  1045
C                                                                        GIONEUT  1046
C                                                                        GIONEUT  1047
C  THIS SUBROUTINE COMPUTES THE VELOCITIES AT THE UPPER BOUNDARY         GIONEUT  1048
C  BY SOLVING OVER THE TOPMOST HEIGHT STEP THE ORDINARY DIFFERENTIAL     GIONEUT  1049
C  EQUATION RESULTING FROM SETTING DN/DT=0 IN THE CONTINUITY EQUATION.   GIONEUT  1050
C                                                                        GIONEUT  1051
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)      GIONEUT  1052
C                                                                        GIONEUT  1053
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                   GIONEUT  1054
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)     GIONEUT  1055
C                                                                        GIONEUT  1056
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,       GIONEUT  1057
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                          GIONEUT  1058
C                                                                        GIONEUT  1059
      COMMON/BOUNDRY/VEL(26)                                             GIONEUT  1060
C                                                                        GIONEUT  1061
      COMMON/RHSIDE/AN,BN,AP,BP,AL,BL                                    GIONEUT  1062
C                                                                        GIONEUT  1063
      REAL N                                                             GIONEUT  1064
      AF(D1,D2,DZ)=(D1-D2)/DZ                                            GIONEUT  1065
      BF(D1,D2,D3,D4,DZ)=(D2*D3-D1*D4)/DZ                                GIONEUT  1066
C                                                                        GIONEUT  1067
      ZE=Z(KMIN1)                                                        GIONEUT  1068
      START=U(KMIN1,I)                                                   GIONEUT  1069
      DZ=DELTAZ(K)                                                       GIONEUT  1070
      D1=N(K,I)                                                          GIONEUT  1071
      D2=N(KMIN1,I)                                                      GIONEUT  1072
      D3=Z(K)*1.0E+05                                                    GIONEUT  1073
      D4=Z(KMIN1)*1.0E+05                                                GIONEUT  1074
      AN=AF(D1,D2,DZ)                                                    GIONEUT  1075
      BN=BF(D1,D2,D3,D4,DZ)                                              GIONEUT  1076
      D1=FORM(K)                                                         GIONEUT  1077
      D2=FORM(KMIN1)                                                     GIONEUT  1078
      AP=AF(D1,D2,DZ)                                                    GIONEUT  1079
      BP=BF(D1,D2,D3,D4,DZ)                                              GIONEUT  1080
      D1=REMV(K)*N(K,I)                                                  GIONEUT  1081
      D2=REMV(KMIN1)*N(KMIN1,I)                                          GIONEUT  1082
      AL=AF(D1,D2,DZ)                                                    GIONEUT  1083
      BL=BF(D1,D2,D3,D4,DZ)                                              GIONEUT  1084
      CALL ODE(1,START,ZE,DZ)                                            GIONEUT  1085
      VEL(I)=START                                                       GIONEUT  1086
      RETURN                                                             GIONEUT  1087
      END                                                                GIONEUT  1088
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      SUBROUTINE ODE(N,START,SZ,DZ)                                     GIONEUT 1089
C                                                                       GIONEUT 1090
C  SUBPROGRAM TO SOLVE A SET OF ORDINARY DIFFERENTIAL EQUATIONS OF      GIONEUT 1091
C  SIZE N USING THE KUTTA-MERSON SCHEME.                                GIONEUT 1092
C                                                                       GIONEUT 1093
      DIMENSION V(7,2),START(2),SLOPE(2)                                GIONEUT 1094
C                                                                       GIONEUT 1095
      DATA IPASS/0/                                                     GIONEUT 1096
C                                                                       GIONEUT 1097
      IF(IPASS .NE. 0) GO TO 1                                          GIONEUT 1098
      C1=1.0/3.0                                                        GIONEUT 1099
      C2=1.0/6.0                                                        GIONEUT 1100
      C3=1.0/8.0                                                        GIONEUT 1101
      C4=3.0/8.0                                                        GIONEUT 1102
      C5=1.0/2.0                                                        GIONEUT 1103
      C6=3.0/2.0                                                        GIONEUT 1104
      C7=2.0/3.0                                                        GIONEUT 1105
      IPASS=1                                                           GIONEUT 1106
1     DO 5 J=1,N                                                        GIONEUT 1107
      V(3,J)=V(1,J)=START(J)                                            GIONEUT 1108
5     CONTINUE                                                          GIONEUT 1109
      ZE=SZ                                                             GIONEUT 1110
      DO 55 II=1,5                                                      GIONEUT 1111
      CALL RHS(ZE,SLOPE,N,V)                                            GIONEUT 1112
      DO 6 J=1,N                                                        GIONEUT 1113
      V(2,J)=SLOPE(J)                                                   GIONEUT 1114
6     CONTINUE                                                          GIONEUT 1115
      GO TO(10,15,20,25,30),II                                          GIONEUT 1116
10    DO 11 J=1,N                                                       GIONEUT 1117
      V(4,J)=V(2,J)*DZ                                                  GIONEUT 1118
      V(1,J)=V(3,J)+C1*V(4,J)                                           GIONEUT 1119
11    CONTINUE                                                          GIONEUT 1120
      GO TO 40                                                          GIONEUT 1121
15    DO 16 J=1,N                                                       GIONEUT 1122
      V(1,J)=V(3,J)+C2*V(4,J)+C2*V(2,J)*DZ                              GIONEUT 1123
16    CONTINUE                                                          GIONEUT 1124
      GO TO 55                                                          GIONEUT 1125
20    DO 21 J=1,N                                                       GIONEUT 1126
      V(5,J)=V(2,J)*DZ                                                  GIONEUT 1127
      V(1,J)=V(3,J)+C3*V(4,J)+C4*V(5,J)                                 GIONEUT 1128
21    CONTINUE                                                          GIONEUT 1129
      GO TO 45                                                          GIONEUT 1130
25    DO 26 J=1,N                                                       GIONEUT 1131
      V(6,J)=V(2,J)*DZ                                                  GIONEUT 1132
      V(1,J)=V(3,J)+C5*V(4,J)-C6*V(5,J)+2.0*V(6,J)                      GIONEUT 1133
      V(7,J)=V(1,J)                                                     GIONEUT 1134
26    CONTINUE                                                          GIONEUT 1135
      GO TO 50                                                          GIONEUT 1136
30    DO 31 J=1,N                                                       GIONEUT 1137
      V(1,J)=V(3,J)+C2*V(4,J)+C7*V(6,J)+C2*V(2,J)*DZ                    GIONEUT 1138
31    CONTINUE                                                          GIONEUT 1139
      GO TO 55                                                          GIONEUT 1140
40    ZE=SZ+C1*DZ*1.0E-05                                               GIONEUT 1141
      GO TO 55                                                          GIONEUT 1142
45    ZE=SZ+C5*DZ*1.0E-05                                               GIONEUT 1143
      GO TO 55                                                          GIONEUT 1144
50    ZE=SZ-DZ*1.0E-05                                                  GIONEUT 1145
```

```
      55    CONTINUE                                                  GIONEUT  1146
            DO 60 J=1,N                                               GIONEUT  1147
      60    START(J)=V(1,J)                                           GIONEUT  1148
      60    CONTINUE                                                  GIONEUT  1149
            RETURN                                                    GIONEUT  1150
            END                                                       GIONEUT  1151
```

```
      SUBROUTINE RHS(ZE,SLOPE,N,V)                                      GIONEUT 1152
C                                                                       GIONEUT 1153
C  THIS SUBROUTINE COMPUTES THE RIGHT HAND SIDE OF THE ORDINARY         GIONEUT 1154
C  DIFFERENTAL EQUATION FOR THE VELOCITY AT THE UPPER BOUNDARY.         GIONEUT 1155
C                                                                       GIONEUT 1156
      DIMENSION V(7,2),SLOPE(2)                                         GIONEUT 1157
C                                                                       GIONEUT 1158
      COMMON/RHSIDE/AN,BN,AP,BP,AL,BL                                   GIONEUT 1159
C                                                                       GIONEUT 1160
      EF(D1,D2,D3)=D1*D2*1.0E+05+D3                                     GIONEUT 1161
C                                                                       GIONEUT 1162
      EN=EF(AN,ZE,BN)                                                   GIONEUT 1163
      EP=EF(AP,ZE,BP)                                                   GIONEUT 1164
      EL=EF(AL,ZE,BL)                                                   GIONEUT 1165
      SLOPE(1)=(EP-EL-V(1,1)*AN)/EN                                     GIONEUT 1166
      RETURN                                                            GIONEUT 1167
      END                                                               GIONEUT 1168
```

```
      SUBROUTINE TIMER                                                  GIONEUT 1169
C                                                                       GIONEUT 1170
C  THIS SUBROUTINE CONTROLS THE TIME AND THE TIME STEP.                 GIONEUT 1171
C                                                                       GIONEUT 1172
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(69_),UZERO(692)     GIONEUT 1173
C                                                                       GIONEUT 1174
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT 1175
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT 1176
C                                                                       GIONEUT 1177
      COMMON GRAV,COSD,SIND,TIME,CHI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT 1178
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                         GIONEUT 1179
C                                                                       GIONEUT 1180
      COMMON/TIMES/DAYS,DELT,TMAX,TSET,TRISE                            GIONEUT 1181
C                                                                       GIONEUT 1182
      COMMON/OUTPUTS/TIMOUT,OPRINT,PRINT                                GIONEUT 1183
C                                                                       GIONEUT 1184
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON          GIONEUT 1185
C                                                                       GIONEUT 1186
      COMMON/LOGIC/NIGHT,DAY,JLOOK,RESET,END                            GIONEUT 1187
C                                                                       GIONEUT 1188
      LOGICAL NIGHT,DAY,JLOOK,RESET,END,PRINT,SET                       GIONEUT 1189
C                                                                       GIONEUT 1190
      COMMON/ALTITUD/ZBOT,ZTOP,TURB,ZTRANS                              GIONEUT 1191
C                                                                       GIONEUT 1192
      DATA SET/.FALSE./                                                 GIONEUT 1193
C                                                                       GIONEUT 1194
      IF(.NOT. SET) GO TO 1                                             GIONEUT 1195
      SET=.FALSE.                                                       GIONEUT 1196
      DELT=15                                                           GIONEUT 1197
    1 RESET=.FALSE.                                                     GIONEUT 1198
      TSEC=TIME+DELT                                                    GIONEUT 1199
      THRS=TSEC/3600.                                                   GIONEUT 1200
      IF(TIMOUT .EQ. 0.) GO TO 8                                        GIONEUT 1201
      IF(THRS.LT.TIMOUT) GOTO 10                                        GIONEUT 1202
      IF(THRS.EQ.TIMOUT) GOTO 8                                         GIONEUT 1203
      TSEC=TIMOUT*3600                                                  GIONEUT 1204
      THRS=TIMOUT                                                       GIONEUT 1205
      DELT=TSEC-TIME                                                    GIONEUT 1206
      RESET=.TRUE.                                                      GIONEUT 1207
    8 PRINT=.TRUE.                                                      GIONEUT 1208
      TIMOUT=TIMOUT+OPRINT                                              GIONEUT 1209
      IF(.NOT. NIGHT) JLOOK=.TRUE.                                      GIONEUT 1210
      GO TO 11                                                          GIONEUT 1211
   10 PRINT=.FALSE.                                                     GIONEUT 1212
   11 OLDMOD=AMOD(TIME,8.64E+04)                                        GIONEUT 1213
C                                                                       GIONEUT 1214
      CHINU=ACOS(COSD*COS(TSEC*RADSEC)+SIND)                            GIONEUT 1215
C                                                                       GIONEUT 1216
C  DETERMINE WHETHER DAY, NIGHT, OR TWILIGHT.                           GIONEUT 1217
C                                                                       GIONEUT 1218
      IF(NIGHT .AND. CHINU .GT. SUNSET(K)) GO TO 15                     GIONEUT 1219
      IF(NIGHT .AND. CHINU .LT. SUNSET(K)) GO TO 5                      GIONEUT 1220
      IF(DAY   .AND. CHINU .LT. SUNSET(1)) GO TO 13                     GIONEUT 1221
      IF(DAY   .AND. CHINU .GT. SUNSET(1)) GO TO 9                      GIONEUT 1222
      IF(CHINU .GT. SUNSET(K)) NIGHT=.TRUE.                             GIONEUT 1223
      IF(CHINU .LT. SUNSET(1)) DAY  =.TRUE.                             GIONEUT 1224
C                                                                       GIONEUT 1225
```

```
C  FIND ALTITUDE OF DAY-NIGHT TRANSITION.                              GIONEUT  1226
C                                                                      GIONEUT  1227
60        IF(DAY .OR. NIGHT) GO TO 26                                  GIONEUT  1228
          DO 6 J=1,K                                                   GIONEUT  1229
          IF(CHINU .LE. SUNSET(J)) GO TO 7                             GIONEUT  1230
6         CONTINUE                                                     GIONEUT  1231
7         ZTRANS=Z(J)                                                  GIONEUT  1232
65        GO TO 26                                                     GIONEUT  1233
C                                                                      GIONEUT  1234
C  RESET THE TIME STEP SO THAT THE NEXT TIME INCREMENT WILL BEGIN      GIONEUT  1235
C  EXACTLY AT SUNRISE AT THE UPPER BOUNDARY.                           GIONEUT  1236
C                                                                      GIONEUT  1237
70        5     DELT=TRISE-OLDMOD                                      GIONEUT  1238
          TSEC=TIME+DELT                                               GIONEUT  1239
          CHINU=SUNSET(K)                                              GIONEUT  1240
          SET=.TRUE.                                                   GIONEUT  1241
          NIGHT=.FALSE.                                                GIONEUT  1242
75        GO TO 15                                                     GIONEUT  1243
C                                                                      GIONEUT  1244
C  RESET THE TIME STEP SO THAT THE NEXT TIME INCREMENT WILL BEGIN      GIONEUT  1245
C  EXACTLY AT SUNSET AT THE LOWER BOUNDARY.                            GIONEUT  1246
C                                                                      GIONEUT  1247
80        9     DELT=TSET-OLDMOD                                       GIONEUT  1248
          TSEC=TIME+DELT                                               GIONEUT  1249
          CHINU=SUNSET(1)                                              GIONEUT  1250
          SET=.TRUE.                                                   GIONEUT  1251
          DAY=.FALSE.                                                  GIONEUT  1252
85        13    ZTRANS=50.                                             GIONEUT  1253
          GO TO 26                                                     GIONEUT  1254
          15    ZTRANS=400.                                            GIONEUT  1255
          26    CHI=CHINU                                              GIONEUT  1256
          TIME=TSEC                                                    GIONEUT  1257
90        RETURN                                                       GIONEUT  1258
          END                                                          GIONEUT  1259
```

```
      SUBROUTINE CHEMION                                                GIONEUT  1260
C                                                                       GIONEUT  1261
C  THIS SUBROUTINE COMPUTES THE SPECIES CONCENTRATIONS TO BE DETERMINED GIONEUT  1262
C  FROM CHEMISTRY ONLY.  THE LARGEST NEGATIVE SPECIES IS COMPUTED       GIONEUT  1263
C  FROM CHARGE BALANCE.                                                 GIONEUT  1264
C                                                                       GIONEUT  1265
      DIMENSION H(1)                                                    GIONEUT  1266
C                                                                       GIONEUT  1267
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     GIONEUT  1268
C                                                                       GIONEUT  1269
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT  1270
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT  1271
C                                                                       GIONEUT  1272
      COMMON GRAV,DOSD,FIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT  1273
     *       K2,KMIN1,ITURB,CXINION,SOYI,NREAC2                         GIONEUT  1274
                                                                        GIONEUT  1275
      COMMON/ESM/OLDN(692,30),OLDCON(424,26),OLDU(692,26),RATES(88,692) GIONEUT  1276
C                                                                       GIONEUT  1277
      COMMON/LOGIC/NIGHT,DAY,JLOOK,RESET,END                            GIONEUT  1278
C                                                                       GIONEUT  1279
      COMMON/TIMES/DAYS,DELT,TMAX,TSET,TRISE                            GIONEUT  1280
C                                                                       GIONEUT  1281
      COMMON/RATECON/AK(88),BK(88),CK(88),DK(215),CYMB(6,215)           GIONEUT  1282
C                                                                       GIONEUT  1283
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)    GIONEUT  1284
C                                                                       GIONEUT  1285
      LEVEL 3, OLDN,OLDCON,OLDU,RATES                                   GIONEUT  1286
      REAL N,NZERO                                                      GIONEUT  1287
      LOGICAL END                                                       GIONEUT  1288
      EQUIVALENCE (U(1,21),H)                                           GIONEUT  1289
C                                                                       GIONEUT  1290
C  COMPUTE O1D PROFILE.                                                 GIONEUT  1291
C                                                                       GIONEUT  1292
      CALL MOVLEV(OLDN(1,27),NZERO,K)                                   GIONEUT  1293
      DO 5 J=1,K                                                        GIONEUT  1294
      CALL CHEM(27,J)                                                   GIONEUT  1295
      N(J,27)=(NZERO(J)+DELT*FORM(J))/(1.0+DELT*REMV(J))                GIONEUT  1296
    5 CONTINUE                                                          GIONEUT  1297
C                                                                       GIONEUT  1298
C  COMPUTE ELECTRON, NEGATIVE ION AND CLUSTER ION PROFILES.             GIONEUT  1299
C                                                                       GIONEUT  1300
      DO 45 J=1,K2                                                      GIONEUT  1301
      DO 10 I=1,3                                                       GIONEUT  1302
      CALL MOVLEV(OLDN(J,I+27),NZERO(I),1)                              GIONEUT  1303
   10 CONTINUE                                                          GIONEUT  1304
      DO 11 I=1,26                                                      GIONEUT  1305
      CALL MOVLEV(OLDCON(J,I),NZERO(I+3),1)                             GIONEUT  1306
   11 CONTINUE                                                          GIONEUT  1307
      DO 60 L=1,500                                                     GIONEUT  1308
      DO 25 I=1,24                                                      GIONEUT  1309
      IF(I .LE. 3) N(I)=N(J,I+27)                                       GIONEUT  1310
      IF(I .GT. 3) H(I)=CONC(J,I-3)                                     GIONEUT  1311
      CALL CHEM(I+27,J)                                                 GIONEUT  1312
      ...(I)=(NZERO(I)+DELT*FORM(J))/(1.0+DELT*REMV(J))                 GIONEUT  1313
   25 CONTINUE                                                          GIONEUT  1314
      ... I=1,3                                                         GIONEUT  1315
      ...                                                               GIONEUT  1316
```

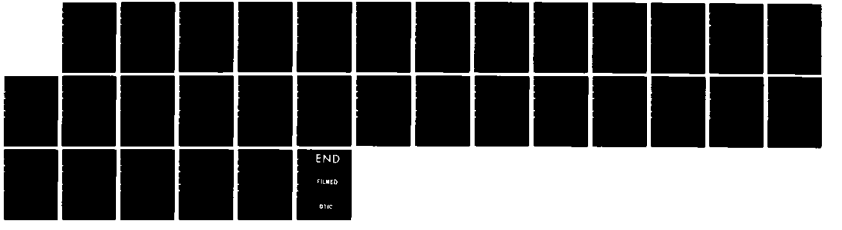
```
      IF(I .LE. 3) N(J,I+27)=DENS                                       GIONEUT 1317
      IF(I .GT. 3) CONC(J,I-3)=DENS                                     GIONEUT 1318
   10 CONTINUE                                                          GIONEUT 1319
C                                                                       GIONEUT 1320
C  FIND LARGEST NEGATIVE SPECIES.                                       GIONEUT 1321
C                                                                       GIONEUT 1322
      BIG=N(J,30)                                                       GIONEUT 1323
      JBIG=1                                                            GIONEUT 1324
      DO 20 I=1,8                                                       GIONEUT 1325
      IF(CONC(J,I) .LT. BIG) GO TO 20                                   GIONEUT 1326
      BIG=CONC(J,I)                                                     GIONEUT 1327
      JBIG=I+1                                                          GIONEUT 1328
   20 CONTINUE                                                          GIONEUT 1329
C                                                                       GIONEUT 1330
C  SUM ALL POSITIVE SPECIES.                                            GIONEUT 1331
C                                                                       GIONEUT 1332
      SUMP=0.                                                           GIONEUT 1333
      DO 30 I=1,8                                                       GIONEUT 1334
      SUMP=SUMP+N(J,I)                                                  GIONEUT 1335
   30 CONTINUE                                                          GIONEUT 1336
      DO 31 I=23,29                                                     GIONEUT 1337
      SUMP=SUMP+N(J,I)                                                  GIONEUT 1338
   31 CONTINUE                                                          GIONEUT 1339
      DO 35 I=9,24                                                      GIONEUT 1340
      SUMP=SUMP+CONC(J,I)                                               GIONEUT 1341
   35 CONTINUE                                                          GIONEUT 1342
C                                                                       GIONEUT 1343
C  SUM ALL NEGATIVE SPECIES EXCEPT LARGEST.                             GIONEUT 1344
C                                                                       GIONEUT 1345
      SUMM=0.                                                           GIONEUT 1346
      DO 40 I=1,9                                                       GIONEUT 1347
      IF(I .EQ. JBIG) GO TO 40                                          GIONEUT 1348
      IF(I .EQ. 1) SUMM=SUMM+N(J,30)                                    GIONEUT 1349
      IF(I .NE. 1) SUMM=SUMM+CONC(J,I-1)                                GIONEUT 1350
   40 CONTINUE                                                          GIONEUT 1351
      DENS=SUMP-SUMM                                                    GIONEUT 1352
      IF(DENS .GT. 0.) GO TO 70                                         GIONEUT 1353
      WRITE(6,75) Z(J),L,JBIG,SUMP,SUMM,DELT                            GIONEUT 1354
      WRITE(6,76) N(J,30),(CONC(J,I),I=1,8)                             GIONEUT 1355
   76 FORMAT(1P9E13.5)                                                  GIONEUT 1356
   75 FORMAT(*  ERROR IN CHEMION.  ALT=*,F8.2,I4,I3,1P3E12.5)           GIONEUT 1357
      END=.TRUE.                                                        GIONEUT 1358
      RETURN                                                            GIONEUT 1359
   70 IF(JBIG .EQ. 1) N(J,30)=DENS                                      GIONEUT 1360
      IF(JBIG .NE. 1) CONC(J,JBIG-1)=DENS                               GIONEUT 1361
      DO 65 I=1,29                                                      GIONEUT 1362
      IF(I .LE. 3) DENS=N(J,I+27)                                       GIONEUT 1363
      IF(I .GT. 3) DENS=CONC(J,I-3)                                     GIONEUT 1364
      IF(DENS .LE. 0.) GO TO 65                                         GIONEUT 1365
      IF(H(I) .EQ. 0.) GO TO 65                                         GIONEUT 1366
      IF(ABS(1.-(DENS/H(I))) .GT. 0.20) GO TO 60                        GIONEUT 1367
   65 CONTINUE                                                          GIONEUT 1368
      GO TO 45                                                          GIONEUT 1369
   60 CONTINUE                                                          GIONEUT 1370
      WRITE(6,80)                                                       GIONEUT 1371
   80 FORMAT(*  ITERATIONS NOT CONVERGING IN CHEMION.*)                 GIONEUT 1372
      WRITE(6,81) Z(J),SYMBOL(I+27),DENS,H(I)                           GIONEUT 1373
```

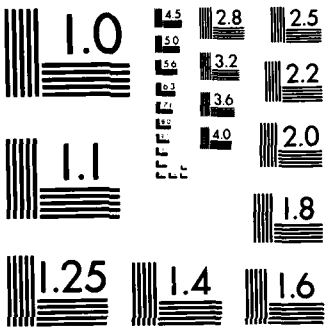
```
115         81    FORMAT(*  FAILURE AT ALTITUDE*,0PF8.2,* FOR SPECIES*,A10,1P2E13.5) GIONEUT  1374
            END=.TRUE.                                                               GIONEUT  1375
            RETURN                                                                   GIONEUT  1376
            45    CONTINUE                                                           GIONEUT  1377
            C                                                                        GIONEUT  1378
120         C  COMPUTE THE MAJOR POSITIVE IONS AND ELECTRONS ABOVE 120 KM.           GIONEUT  1379
            C                                                                        GIONEUT  1380
            KB=K2+1                                                                  GIONEUT  1381
            CALL MOVLEV(OLDN(1,28),E,K)                                              GIONEUT  1382
            CALL MOVLEV(OLDN(1,29),F,K)                                              GIONEUT  1383
125         DO 105 J=KB,K                                                            GIONEUT  1384
            DO 100 L=1,500                                                           GIONEUT  1385
            DO 110 I=1,2                                                             GIONEUT  1386
            H(I)=N(J,I+27)                                                           GIONEUT  1387
            CALL CHEM(I+27,J)                                                        GIONEUT  1388
130         IF(I .EQ. 1) DENS=E(J)                                                   GIONEUT  1389
            IF(I .EQ. 2) DENS=F(J)                                                   GIONEUT  1390
            H(I+3)=(DENS+DELT*FORM(J))/(1.0+DELT*REMV(J))                            GIONEUT  1391
            110   CONTINUE                                                           GIONEUT  1392
            DO 91 I=1,2                                                              GIONEUT  1393
135         N(J,I+27)=H(I+3)                                                         GIONEUT  1394
            91    CONTINUE                                                           GIONEUT  1395
            DO 95 I=1,2                                                              GIONEUT  1396
            IF(H(I) .EQ. 0.) GO TO 95                                                GIONEUT  1397
            IF(ABS(1.0-(N(J,I+27)/H(I))) .GT. 0.1) GO TO 100                         GIONEUT  1398
140         95    CONTINUE                                                           GIONEUT  1399
            GO TO 105                                                                GIONEUT  1400
            100   CONTINUE                                                           GIONEUT  1401
            105   CONTINUE                                                           GIONEUT  1402
            DO 55 J=KB,K                                                             GIONEUT  1403
145         SUMP=0.                                                                  GIONEUT  1404
            DO 50 I=1,6                                                              GIONEUT  1405
            SUMP=SUMP+N(J,I)                                                         GIONEUT  1406
            50    CONTINUE                                                           GIONEUT  1407
            DO 51 I=28,29                                                            GIONEUT  1408
150         SUMP=SUMP+N(J,I)                                                         GIONEUT  1409
            51    CONTINUE                                                           GIONEUT  1410
            N(J,30)=SUMP                                                             GIONEUT  1411
            55    CONTINUE                                                           GIONEUT  1412
            RETURN                                                                   GIONEUT  1413
155         END                                                                      GIONEUT  1414
```

```
      SUBROUTINE CHEM(KIND,IALT)
C
C     THIS SUBROUTINE COMPUTES THE CHEMICAL FORMATION AND REMOVAL RATES
C     SPECIFIC KIND AT THE ALTITUDE WHOSE INDEX IS J.
C
      DIMENSION Y(57),K(215)
C
      COMMON N(692,30),CONC(424,26),L(692,26),NZERO(692),UZERO(692)
C
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),
     1       LED(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)
C
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,KTOP,
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2
C
      COMMON/RATECON,AK(88),BK(88),CK(88),DK(215),CYMB(6,215)
C
      COMMON/ESAV/OLDN(692,30),OLDCON(424,26),OLDU(692,26),RATES(88,692)
C
      COMMON/LOGIC/NIGHT,DAY,OLDOK,RESET,END
C
      LEVEL [illegible] ,OLDCON,OLDU,RATES
C
      LOGICAL NIGHT
      REAL K,N
C
      DO 500 I=1,ISPECI
      IF(I .GT. 30) GO TO 200
      Y(I)=N(IALT,I)
      GO TO 500
  200 IF(IALT .GT. K2) GO TO 475
      Y(I)=CONC(IALT,I-30)
      GO TO 500
  475 Y(I)=0.
  500 CONTINUE
      Y(57)=0.
      DO 600 I=1,ISPECI
      Y(57)=Y(57)+Y(I)
  600 CONTINUE
      DO 205 I=1,NREAC
      K(I)=DK(I)
  205 CONTINUE
      IF(.NOT. NIGHT) GO TO 210
      K(96)=K(99)=K(104)=K(105)=K(110)=0.
      K(113)=K(114)=K(118)=K(120)=K(123)=0.
  210 CALL MOVLEV(RATES(1,IALT),K(128),88)
      IF(IALT .LE. K2) GO TO 215
      K(31)=K(32)=K(35)=0.
      K(16[illegible])=K(1[illegible])=K(152)=K(165)=K(166)=0.
  215 GO TO(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,
     1 24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,
     2 46,47,48,49,50,51,52,53,54,55,56),KIND
      CONTINUE
      RMOV[illegible]K(4)*Y([illegible])+K(159)*Y(30))
      [illegible]
      GO TO [illegible]0
    2 CONTINUE
```

AD-A157 122 A COMPUTER CODE FOR A ONE-DIMENSIONAL DYNAMIC MODEL OF THE MESOSPHERS AND.. (U) AIR FORCE GEOPHYSICS LAB HANSCOM AFB MA T J KENESHEA ET AL. 07 MAR 84 3/3

UNCLASSIFIED AFGL-TR-84-0183 F/G 4/1 NL





MICROCOPY RESOLUTION TEST CHART

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      RMOV=(Y(8)*(+K(45)+K(46))+Y(23)*(+K(47)+K(48))+K(49)*Y(18))                GIONEUT  1472
      FARM=(+K(191)*Y(21))                                                      GIONEUT  1473
   60 GO TO 100                                                                 GIONEUT  1474
    3 CONTINUE                                                                  GIONEUT  1475
      RMOV=(+K(40)*Y(11)+K(127)*Y(25)+K(153)*Y(30)+K(168)*Y(23)+K(169)*Y       GIONEUT  1476
     1(8))                                                                      GIONEUT  1477
      FARM=(Y(7)*(+K(41)*Y(1)+K(185)+K(211))+Y(8)*(+K(45)*Y(2)+K(209)))         GIONEUT  1478
   65 GO TO 100                                                                 GIONEUT  1479
    4 CONTINUE                                                                  GIONEUT  1480
      RMOV=(+K(33)*Y(18)+K(34)*Y(16)+K(35)*Y(19)+K(152)*Y(30)+K(162)*Y(8       GIONEUT  1481
     1)*Y(57))                                                                  GIONEUT  1482
      FARM=(Y(8)*(Y(6)*(+K(43)+K(44))+K(46)*Y(2)+K(126)*Y(29)+K(167)*Y(2        GIONEUT  1483
   70 1)8)+K(169)*Y(3)+K(186)+K(214))+Y(39)*(+K(36)*Y(7)+K(163)*Y(57)+K(16      GIONEUT  1484
     1)4)*Y(20))+K(127)*Y(3)*Y(25)+K(207)*Y(20))                                GIONEUT  1485
      GO TO 100                                                                 GIONEUT  1486
    5 CONTINUE                                                                  GIONEUT  1487
      RMOV=(Y(30)*(+K(150)+K(151))+K(165)*Y(25)*Y(23)+K(166)*Y(13)*Y(57)        GIONEUT  1488
   75 1)                                                                        GIONEUT  1489
      FARM=(Y(18)*(+K(33)*Y(4)+K(50)*Y(40)+K(188))+Y(7)*(+K(38)*Y(28)+K(        GIONEUT  1490
     1)39)*Y(28))+K(34)*Y(4)*Y(16)+K(42)*Y(6)*Y(8)+K(168)*Y(3)*Y(23))           GIONEUT  1491
      GO TO 100                                                                 GIONEUT  1492
    6 CONTINUE                                                                  GIONEUT  1493
   80 RMOV=(Y(8)*(+K(42)+K(43)+K(44))+K(154)*Y(30))                             GIONEUT  1494
      FARM=(Y(2)*(+K(47)*Y(23)+K(49)*Y(18))+K(189)*Y(16)+K(208)*Y(23))          GIONEUT  1495
      GO TO 100                                                                 GIONEUT  1496
    7 CONTINUE                                                                  GIONEUT  1497
      RMOV=(Y(57)*(Y(7)*(+K(128)+K(128))+K(129)*Y(8)+K(139)*Y(16)+K(143)        GIONEUT  1498
   85 1*Y(18)+K(148)*Y(26))+Y(14)*(+K(132)+K(133))+Y(28)*(+K(38)+K(39))+Y       GIONEUT  1499
     1(32)*(+K(100)+K(101))+Y(34)*(+K(107)+K(108))+K(2)*Y(10)+K(3)*Y(12)        GIONEUT  1500
     1+K(4)*Y(19)+K(20)*Y(55)+K(31)*Y(30)+K(36)*Y(39)+K(41)*Y(1)+K(97)*Y        GIONEUT  1501
     1(31)+K(106)*Y(33)+K(111)*Y(37)+K(115)*Y(38)+K(121)*Y(36)+K(130)*Y(       GIONEUT  1502
     19)+K(131)*Y(15)+K(185)+K(206)+K(211)+K(212))                              GIONEUT  1503
   90 FARM=(Y(8)*(+K(14)*Y(17)+K(42)*Y(6)+K(45)*Y(2)+K(126)*Y(29)+K(137)        GIONEUT  1504
     1*Y(16)+K(169)*Y(3)+K(192)+K(192)+K(193)+K(209)+K(210))+Y(30)*(Y(4)        GIONEUT  1505
     1*(+K(152)+K(152))+Y(5)*(+K(150)+K(151))+K(153)*Y(3)+K(156)*Y(40))+       GIONEUT  1506
     1Y(16)*(+K(9)*Y(19)+K(34)*Y(4)+K(138)*Y(18))+Y(9)*(+K(98)*Y(31)+K(1       GIONEUT  1507
     194))+Y(18)*(+K(49)*Y(2)+K(199))+K(12)*Y(10)+K(16)*Y(27)*Y(57             GIONEUT  1508
   95 1)+K(40)*Y(3)*Y(11)+K(96)*Y(31)+K(120)*Y(36)+K(125)*Y(29)*Y(23)+K(2       GIONEUT  1509
     104)*Y(25))                                                                GIONEUT  1510
      GO TO 100                                                                 GIONEUT  1511
    8 CONTINUE                                                                  GIONEUT  1512
      RMOV=(Y(8)*(Y(30)*(+K(160)+K(160))+Y(31)*(+K(179)+K(179))+Y(32)*(+        GIONEUT  1513
  100 1K(180)+K(180)))+Y(6)*(+K(42)+K(43)+K(44))+Y(57)*(+K(129)*Y(7)+K(13       GIONEUT  1514
     16)*Y(11)+K(162)*Y(4))+Y(2)*(+K(45)+K(46))+K(14)*Y(17)+K(32)*Y(23)*       GIONEUT  1515
     1Y(30)+K(126)*Y(29)+K(137)*Y(16)+K(167)*Y(28)+K(169)*Y(3)+K(186)+K(       GIONEUT  1516
     1192)+K(193)+K(209)+K(210)+K(214))                                         GIONEUT  1517
      FARM=(Y(7)*(Y(34)*(+K(107)+K(108)+K(108))+Y(9)*(+K(130)+K(130))+K(        GIONEUT  1518
  105 12)*Y(10)+K(3)*Y(12)+K(4)*Y(19)+K(97)*Y(31)+K(101)*Y(32)+K(106)*Y(3       GIONEUT  1519
     13)+K(115)*Y(38)+K(121)*Y(36)+K(128)*Y(7)*Y(57)+K(133)*Y(14))+Y(9)*       GIONEUT  1520
     1(Y(12)*(+K(145)+K(145))+K(7)*Y(11)+K(8)*Y(16)+K(102)*Y(32)+K(116)*       GIONEUT  1521
     1Y(38)+K(119)*Y(35)+K(124)*Y(31)+K(140)*Y(10)+K(142)*Y(18)+K(161)*Y       GIONEUT  1522
     1(30)+K(194))+Y(20)*(Y(32)*(+K(103)+K(103))+Y(39)*(+K(164)+K(164))+       GIONEUT  1523
  110 1K(18)*Y(57)+K(19))+Y(12)*(+K(5)*Y(11)+K(13)*Y(10)+K(144)*Y(12)+K(1       GIONEUT  1524
     198))+Y(8)*(Y(8)*(+K(160)*Y(30)+K(179)*Y(31)+K(180)*Y(32)))+Y(13)*(       GIONEUT  1525
     1Y(50)*(+K(53)+K(54))+K(37)*Y(39))+Y(4)*(+K(33)*Y(18)+K(35)*Y(19))+       GIONEUT  1526
     1Y(25)*(+K(109)*Y(34)+K(182)*Y(33))+Y(57)*(+K(163)*Y(39)+K(183)*Y(3       GIONEUT  1527
     14))+K(11)*Y(16)*Y(19)+K(99)*Y(32)+K(105)*Y(33)+K(114)*Y(38)+K(205)       GIONEUT  1528
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      1*Y(56))                                                          GIONEUT  1529
       GO TO 100                                                        GIONEUT  1530
    9 CONTINUE                                                          GIONEUT  1531
       RMOV=(Y(31)*(+K(98)+K(124))+K(7)*Y(11)+K(8)*Y(16)+K(102)*Y(32)+K(1 GIONEUT  1532
      116)*Y(38)+K(119)*Y(35)+K(130)*Y(7)+K(140)*Y(10)+K(142)*Y(18)+K(145 GIONEUT  1533
      1)*Y(12)+K(161)*Y(30)+K(194)+K(195))                              GIONEUT  1534
       FARM=(Y(7)*(+K(36)*Y(39)+K(100)*Y(32)+K(129)*Y(8)*Y(57))+K(104)*Y( GIONEUT  1535
      133))                                                             GIONEUT  1536
       GO TO 100                                                        GIONEUT  1537
   10 CONTINUE                                                          GIONEUT  1538
       RMOV=(Y(10)*(+K(12)+K(12))+K(2)*Y(7)+K(13)*Y(12)+K(21)*Y(55)+K(140 GIONEUT  1539
      1)*Y(9)+K(141)*Y(14)+K(147)*Y(26))                                GIONEUT  1540
       FARM=(Y(37)*(+K(64)*Y(41)+K(68)*Y(42)+K(72)*Y(43)+K(76)*Y(44)+K(80 GIONEUT  1541
      1)*Y(45)+K(92)*Y(48)+K(94)*Y(49))+Y(30)*(+K(24)*Y(41)+K(25)*Y(42)+K GIONEUT  1542
      1(26)*Y(43)+K(27)*Y(44)+K(28)*Y(45)+K(29)*Y(47))+Y(11)*(Y(12)*(+K(6 GIONEUT  1543
      1)+K(6))+K(7)*Y(9)+K(135)*Y(14)+K(146)*Y(19))+Y(13)*(Y(27)*(+K(15)+ GIONEUT  1544
      1K(15))+K(54)*Y(50)+K(61)*Y(47)+K(196))+Y(36)*(+K(63)*Y(41)+K(67)*Y GIONEUT  1545
      1(42)+K(71)*Y(43)+K(75)*Y(44)+K(79)*Y(45))+Y(7)*(+K(3)*Y(12)+K(20)* GIONEUT  1546
      1Y(55)+K(131)*Y(15)+K(132)*Y(14))+Y(14)*(+K(197)+K(197))+K(17)*Y(27 GIONEUT  1547
      1)*Y(15)+K(145)*Y(12)*Y(9)+K(202)*Y(55))                          GIONEUT  1548
       GO TO 100                                                        GIONEUT  1549
   11 CONTINUE                                                          GIONEUT  1550
       RMOV=(Y(12)*(+K(5)+K(6))+Y(14)*(+K(134)+K(135))+K(7)*Y(9)+K(40)*Y( GIONEUT  1551
      13)+K(136)*Y(8)*Y(57)+K(146)*Y(19)+K(190))                        GIONEUT  1552
       FARM=(Y(35)*(+K(62)*Y(41)+K(66)*Y(42)+K(70)*Y(43)+K(74)*Y(44)+K(78 GIONEUT  1553
      1)*Y(45))+Y(7)*(+K(2)*Y(10)+K(41)*Y(1)+K(131)*Y(15))+Y(30)*(+K(29)* GIONEUT  1554
      1Y(47)+K(30)*Y(49)+K(155)*Y(1))+K(17)*Y(27)*Y(15)+K(147)*Y(26)*Y(10 GIONEUT  1555
      1)+K(196)*Y(13)+K(198)*Y(12))                                     GIONEUT  1556
       GO TO 100                                                        GIONEUT  1557
   12 CONTINUE                                                          GIONEUT  1558
       RMOV=(Y(11)*(+K(5)+K(6))+Y(12)*(+K(144)+K(144))+K(3)*Y(7)+K(13)*Y( GIONEUT  1559
      110)+K(145)*Y(9)+K(198))                                          GIONEUT  1560
       FARM=(Y(38)*(+K(69)*Y(42)+K(73)*Y(43)+K(77)*Y(44)+K(81)*Y(45)+K(93 GIONEUT  1561
      1)*Y(48)+K(95)*Y(49))+Y(14)*(+K(132)*Y(7)+K(134)*Y(11)+K(141)*Y(10) GIONEUT  1562
      1)+K(65)*Y(42)*Y(32)+K(136)*Y(11)*Y(8)*Y(57)+K(140)*Y(10)*Y(9))   GIONEUT  1563
       GO TO 100                                                        GIONEUT  1564
   13 CONTINUE                                                          GIONEUT  1565
       RMOV=(Y(57)*(+K(52)*Y(44)+K(166)*Y(5)+K(170)*Y(41)+K(172)*Y(42)+K( GIONEUT  1566
      1173)*Y(43)+K(177)*Y(51)+K(178)*Y(52))+Y(48)*(+K(58)*Y(23)+K(60))+Y GIONEUT  1567
      1(50)*(+K(53)+K(54))+K(15)*Y(27)+K(37)*Y(39)+K(55)*Y(53)+K(56)*Y(54 GIONEUT  1568
      1)+K(59)*Y(49)+K(61)*Y(47)+K(196))                                GIONEUT  1569
       FARM=(Y(30)*(Y(52)*(+K(158)+K(158))+K(25)*Y(42)+K(29)*Y(47)+K(157) GIONEUT  1570
      1*Y(51))+Y(10)*(+K(12)*Y(10)+K(13)*Y(12)+K(21)*Y(55)+K(141)*Y(14))+ GIONEUT  1571
      1Y(37)*(+K(64)*Y(41)+K(84)*Y(51)+K(92)*Y(48))+Y(57)*(+K(174)*Y(43)+ GIONEUT  1572
      1K(175)*Y(44)+K(176)*Y(45))+Y(14)*(+K(133)*Y(7)+K(135)*Y(11))+Y(32) GIONEUT  1573
      1*(+K(65)*Y(42)+K(65)*Y(42))+Y(35)*(+K(62)*Y(41)+K(82)*Y(51))+Y(36) GIONEUT  1574
      1*(+K(63)*Y(41)+K(83)*Y(51))+K(93)*Y(48)*Y(38))                   GIONEUT  1575
       FARM=FARM+2.0*(Y(42)*(K(66)*Y(35)+K(67)*Y(36)+K(68)*Y(37)         GIONEUT  1576
      1+K(69)*Y(38))+Y(49)*(K(30)*Y(30)+K(94)*Y(37)+K(95)*Y             GIONEUT  1577
      2(38))+Y(52)*(K(85)*Y(35)+K(86)*Y(36)+K(87)*Y(37))                GIONEUT  1578
      3+K(26)*Y(43)*Y(30))+3.0*(Y(43)*(K(70)*Y(35)+K(71)*               GIONEUT  1579
      4Y(36)+K(72)*Y(37)+K(73)*Y(38))+Y(53)*(K(88)*Y(35)                GIONEUT  1580
      5+K(89)*Y(36)+K(90)*Y(37)+K(159)*Y(30))+K(27)*Y(44)               GIONEUT  1581
      6*Y(30))+4.0*(Y(44)*(K(74)*Y(35)+K(75)*Y(36)+K(76)*Y(             GIONEUT  1582
      737)+K(77)*Y(38))+K(28)*Y(45)*Y(30))+5.0*(Y(45)*(                 GIONEUT  1583
      8K(78)*Y(35)+K(79)*Y(36)+K(80)*Y(37)+K(81)*Y(38)))                GIONEUT  1584
       GO TO 100                                                        GIONEUT  1585
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      14 CONTINUE                                                                GIONEUT  1586
         RMOV=(Y(7)*(+K(132)+K(133))+Y(11)*(+K(134)+K(135))+K(141)*Y(10)+K(      GIONEUT  1587
        1197))                                                                   GIONEUT  1588
  175    FARM=(+K(91)*Y(48)*Y(36)+K(144)*Y(12)*Y(12))                            GIONEUT  1589
         GO TO 100                                                               GIONEUT  1590
      15 CONTINUE                                                                GIONEUT  1591
         RMOV=(+K(17)*Y(27)+K(131)*Y(7))                                         GIONEUT  1592
         FARM=(Y(30)*(+K(24)*Y(41)+K(25)*Y(42)+K(26)*Y(43)+K(27)*Y(44)+K(28      GIONEUT  1593
  180   1)*Y(45))+Y(11)*(+K(5)*Y(12)+K(134)*Y(14)))                              GIONEUT  1594
         GO TO 100                                                               GIONEUT  1595
      16 CONTINUE                                                                GIONEUT  1596
         RMOV=(Y(19)*(+K(9)+K(10)+K(11))+K(8)*Y(9)+K(34)*Y(4)+K(137)*Y(8)+K      GIONEUT  1597
        1(138)*Y(18)+K(139)*Y(7)*Y(57)+K(189))                                   GIONEUT  1598
  185    FARM=(Y(30)*(Y(28)*(+K(22)+K(22))+K(149)*Y(17)+K(150)*Y(5)+K(154)*      GIONEUT  1599
        1Y(6))+Y(23)*(+K(47)*Y(2)+K(168)*Y(3)+K(208)+K(215))+Y(7)*(+K(1)*Y(      GIONEUT  1600
        117)+K(38)*Y(28))+K(43)*Y(6)*Y(8)+K(199)*Y(18))                          GIONEUT  1601
         GO TO 100                                                               GIONEUT  1602
      17 CONTINUE                                                                GIONEUT  1603
  190    RMOV=(+K(1)*Y(7)+K(14)*Y(8)+K(149)*Y(30))                               GIONEUT  1604
         FARM=(Y(28)*(Y(30)*(+K(23)+K(23))+K(39)*Y(7))+K(44)*Y(6)*Y(8)+K(15      GIONEUT  1605
        11)*Y(5)*Y(30)+K(215)*Y(23))                                             GIONEUT  1606
         GO TO 100                                                               GIONEUT  1607
      18 CONTINUE                                                                GIONEUT  1608
  195    RMOV=(+K(33)*Y(4)+K(49)*Y(2)+K(50)*Y(40)+K(117)*Y(38)+K(122)*Y(56)      GIONEUT  1609
        1+K(138)*Y(16)+K(142)*Y(9)+K(143)*Y(7)*Y(57)+K(184)*Y(37)+K(188)+K(      GIONEUT  1610
        1199))                                                                   GIONEUT  1611
         FARM=(Y(16)*(Y(19)*(+K(10)+K(10))+K(8)*Y(9)+K(137)*Y(8)+K(139)*Y(7      GIONEUT  1612
        1)*Y(57))+Y(30)*(+K(156)*Y(40)+K(157)*Y(51)+K(158)*Y(52)+K(159)*Y(5      GIONEUT  1613
  200   13))+Y(19)*(+K(4)*Y(7)+K(146)*Y(11)+K(200))+Y(35)*(+K(82)*Y(51)+K(8      GIONEUT  1614
        15)*Y(52)+K(88)*Y(53))+K(14)*Y(17)*Y(8)+K(202)*Y(55)+K(205)*Y(56))      GIONEUT  1615
         GO TO 100                                                               GIONEUT  1616
      19 CONTINUE                                                                GIONEUT  1617
         RMOV=(Y(16)*(+K(9)+K(10)+K(11))+K(4)*Y(7)+K(35)*Y(4)+K(112)*Y(37)+      GIONEUT  1618
  205   1K(146)*Y(11)+K(200))                                                    GIONEUT  1619
         FARM=(Y(36)*(Y(51)*(+K(83)+K(83))+Y(52)*(+K(86)+K(86))+Y(53)*(+K(8      GIONEUT  1620
        19)+K(89))+K(63)*Y(41)+K(67)*Y(42)+K(71)*Y(43)+K(75)*Y(44)+K(79)*Y(      GIONEUT  1621
        145))+Y(35)*(+K(62)*Y(41)+K(66)*Y(42)+K(70)*Y(43)+K(74)*Y(44)+K(78)      GIONEUT  1622
        1*Y(45)+K(82)*Y(51)+K(85)*Y(52)+K(88)*Y(53)+K(118))+Y(18)*(Y(56)*(+      GIONEUT  1623
  210   1K(122)+K(122))+K(50)*Y(40)+K(142)*Y(9)+K(143)*Y(7)*Y(57))+Y(37)*(+      GIONEUT  1624
        1K(84)*Y(51)+K(87)*Y(52)+K(90)*Y(53))+Y(55)*(+K(20)*Y(7)+K(21)*Y(10      GIONEUT  1625
        1)))                                                                     GIONEUT  1626
         GO TO 100                                                               GIONEUT  1627
      20 CONTINUE                                                                GIONEUT  1628
  215    RMOV=(+K(18)*Y(57)+K(19)+K(103)*Y(32)+K(164)*Y(39)+K(207))              GIONEUT  1629
         FARM=(+K(195)*Y(9))                                                     GIONEUT  1630
         GO TO 100                                                               GIONEUT  1631
      21 CONTINUE                                                                GIONEUT  1632
         RMOV=(+K(191))                                                          GIONEUT  1633
  220    FARM=(Y(2)*(Y(8)*(+K(45)+K(46))+Y(23)*(+K(47)+K(48))+K(49)*Y(18)))      GIONEUT  1634
         GO TO 100                                                               GIONEUT  1635
      22 CONTINUE                                                                GIONEUT  1636
         RMOV=0.                                                                 GIONEUT  1637
         FARM=0.                                                                 GIONEUT  1638
  225    GO TO 100                                                               GIONEUT  1639
      23 CONTINUE                                                                GIONEUT  1640
         RMOV=(Y(2)*(+K(47)+K(48))+Y(23)*(-K(171)*Y(41)+K(171)*Y(41))+K(125      GIONEUT  1641
        1)*Y(29)+K(168)*Y(3)+K(187)+K(208)+K(213)+K(215))                        GIONEUT  1642
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      FARM=(Y(16)*(+K(11)*Y(19)+K(138)*Y(18))+K(57)*Y(46)*Y(25)+K(167)*Y  GIONEUT  1643
     1(28)*Y(8)+K(171)*Y(41)*Y(23)*Y(23)+K(201)*Y(24))                    GIONEUT  1644
      GO TO 100                                                           GIONEUT  1645
   24 CONTINUE                                                            GIONEUT  1646
      RMOV=(+K(201))                                                      GIONEUT  1647
      FARM=(+K(9)*Y(16)*Y(19))                                            GIONEUT  1648
      GO TO 100                                                           GIONEUT  1649
   25 CONTINUE                                                            GIONEUT  1650
      RMOV=(+K(51)*Y(42)*Y(57)+K(57)*Y(46)+K(109)*Y(34)+K(127)*Y(3)+K(16  GIONEUT  1651
     15)*Y(5)*Y(23)+K(181)*Y(32)*Y(8)+K(182)*Y(33)+K(203)+K(204))         GIONEUT  1652
      FARM=(Y(37)*(+K(64)*Y(41)+K(68)*Y(42)+K(72)*Y(43)+K(76)*Y(44)+K(80  GIONEUT  1653
     1)*Y(45)+K(84)*Y(51)+K(87)*Y(52)+K(90)*Y(53)+K(110)+K(111)*Y(7)+K(1  GIONEUT  1654
     112)*Y(19)+K(184)*Y(18))+Y(38)*(+K(69)*Y(42)+K(73)*Y(43)+K(77)*Y(44  GIONEUT  1655
     1)+K(81)*Y(45)+K(113)+K(114)+K(116)*Y(9)+K(117)*Y(18))+Y(13)*(+K(56  GIONEUT  1656
     1)*Y(54)+K(59)*Y(49)+K(60)*Y(48))+Y(26)*(+K(147)*Y(10)+K(148)*Y(7)*  GIONEUT  1657
     1Y(57))+K(30)*Y(45)*Y(30)+K(91)*Y(48)*Y(36))                         GIONEUT  1658
      FARM=FARM+2.0*(Y(37)*(K(92)*Y(48)+K(94)*Y(49))+Y(38)*(              GIONEUT  1659
     1K(93)*Y(48)+K(95)*Y(49)))                                           GIONEUT  1660
      GO TO 100                                                           GIONEUT  1661
   26 CONTINUE                                                            GIONEUT  1662
      RMOV=(+K(147)*Y(10)+K(148)*Y(7)*Y(57))                              GIONEUT  1663
      FARM=(Y(25)*(+K(127)*Y(3)+K(203)+K(204)))                           GIONEUT  1664
      GO TO 100                                                           GIONEUT  1665
   27 CONTINUE                                                            GIONEUT  1666
      RMOV=(+K(15)*Y(13)+K(16)*Y(57)+K(17)*Y(15))                         GIONEUT  1667
      FARM=(+K(193)*Y(8)+K(195)*Y(9)+K(200)*Y(19)+K(201)*Y(24)+K(203)*Y(  GIONEUT  1668
     125))                                                                GIONEUT  1669
      GO TO 100                                                           GIONEUT  1670
   28 CONTINUE                                                            GIONEUT  1671
      RMOV=(Y(7)*(+K(38)+K(39))+Y(30)*(+K(22)+K(23))+K(167)*Y(8))         GIONEUT  1672
      FARM=(Y(23)*(+K(48)*Y(2)+K(125)*Y(29)+K(187)+K(213)))               GIONEUT  1673
      GO TO 100                                                           GIONEUT  1674
   29 CONTINUE                                                            GIONEUT  1675
      RMOV=(+K(125)*Y(23)+K(126)*Y(8))                                    GIONEUT  1676
      FARM=(Y(7)*(+K(206)+K(212))+K(210)*Y(8))                            GIONEUT  1677
      GO TO 100                                                           GIONEUT  1678
   30 CONTINUE                                                            GIONEUT  1679
      RMOV=(Y(5)*(+K(150)+K(151))+Y(8)*(+K(32)*Y(23)+K(160)*Y(8))+Y(28)*  GIONEUT  1680
     1(+K(22)+K(23))+K(24)*Y(41)+K(25)*Y(42)+K(26)*Y(43)+K(27)*Y(44)+K(2  GIONEUT  1681
     18)*Y(45)+K(29)*Y(47)+K(30)*Y(49)+K(31)*Y(7)+K(152)*Y(4)+K(153)*Y(3  GIONEUT  1682
     1)+K(154)*Y(6)+K(155)*Y(1)+K(156)*Y(40)+K(157)*Y(51)+K(158)*Y(52)+K  GIONEUT  1683
     1(159)*Y(53)+K(161)*Y(9))                                            GIONEUT  1684
      FARM=(Y(7)*(+K(97)*Y(31)+K(100)*Y(32)+K(185)+K(206))+Y(20)*(+K(103  GIONEUT  1685
     1)*Y(32)+K(207))+Y(23)*K(187)+K(96)*Y(31)+K(99)*Y(32)+K(1            GIONEUT  1686
     104)*Y(33)+K(114)*Y(38)+K(118)*Y(35)+K(123)*Y(36)+K(186)*Y(8)+K(188  GIONEUT  1687
     1)*Y(18)+K(189)*Y(16)+K(190)*Y(11)+K(191)*Y(21))                     GIONEUT  1688
      FARM=FARM+Y(23)*(K(208)+K(213))+Y(8)*(K(209)+K(210)+K(214))         GIONEUT  1689
     1+Y(7)*(K(211)+K(212))                                               GIONEUT  1690
      GO TO 100                                                           GIONEUT  1691
   31 CONTINUE                                                            GIONEUT  1692
      RMOV=(Y(9)*(+K(98)+K(124))+K(96)+K(97)*Y(7)+K(179)*Y(8)*Y(8))       GIONEUT  1693
      FARM=(Y(7)*(+K(31)*Y(30)+K(101)*Y(32)+K(108)*Y(34))+K(105)*Y(33)+K  GIONEUT  1694
     1(110)*Y(37)+K(181)*Y(9)*Y(30))                                      GIONEUT  1695
      GO TO 100                                                           GIONEUT  1696
   32 CONTINUE                                                            GIONEUT  1697
      RMOV=(Y(7)*(+K(100)+K(101))+Y(8)*(+K(180)*Y(8)+K(181)*Y(25))+K(65)  GIONEUT  1698
     1+Y(42)+K(99)+K(102)*Y(9)+K(103)*Y(20))                              GIONEUT  1699
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      FARM=(Y(7)*(+K(106)*Y(33)+K(111)*Y(37))+Y(8)*(Y(30)*(+K(32)*Y(23)+ GIONEUT  1700
     1K(160)*Y(8)))+K(113)*Y(38)+K(124)*Y(31)*Y(9)+K(183)*Y(34)*Y(57))   GIONEUT  1701
      GO TO 100                                                          GIONEUT  1702
   33 CONTINUE                                                           GIONEUT  1703
  290 RMOV=(+K(104)+K(105)+K(106)*Y(7)+K(182)*Y(25))                     GIONEUT  1704
      FARM=(Y(9)*(+K(98)*Y(31)+K(102)*Y(32)+K(116)*Y(38))+K(107)*Y(34)*Y GIONEUT  1705
     1(7)+K(179)*Y(31)*Y(8)*Y(8))                                        GIONEUT  1706
      GO TO 100                                                          GIONEUT  1707
   34 CONTINUE                                                           GIONEUT  1708
  295 RMOV=(Y(7)*(+K(107)+K(108))+K(109)*Y(25)+K(183)*Y(57))             GIONEUT  1709
      FARM=(+K(180)*Y(32)*Y(8)*Y(8))                                     GIONEUT  1710
      GO TO 100                                                          GIONEUT  1711
   35 CONTINUE                                                           GIONEUT  1712
      RMOV=(+K(62)*Y(41)+K(66)*Y(42)+K(70)*Y(43)+K(74)*Y(44)+K(78)*Y(45) GIONEUT  1713
  300 1+K(82)*Y(51)+K(85)*Y(52)+K(88)*Y(53)+K(118)+K(119)*Y(9))          GIONEUT  1714
      FARM=(Y(36)*(+K(120)+K(121)*Y(7))+K(184)*Y(37)*Y(18))              GIONEUT  1715
      GO TO 100                                                          GIONEUT  1716
   36 CONTINUE                                                           GIONEUT  1717
      RMOV=(+K(63)*Y(41)+K(67)*Y(42)+K(71)*Y(43)+K(75)*Y(44)+K(79)*Y(45) GIONEUT  1718
  305 1+K(83)*Y(51)+K(86)*Y(52)+K(89)*Y(53)+K(91)*Y(48)+K(120)+K(121)*Y(7 GIONEUT  1719
     1)+K(123))                                                          GIONEUT  1720
      FARM=(+K(112)*Y(37)*Y(19)+K(117)*Y(38)*Y(18)+K(119)*Y(35)*Y(9))    GIONEUT  1721
      GO TO 100                                                          GIONEUT  1722
   37 CONTINUE                                                           GIONEUT  1723
  310 RMOV=(+K(64)*Y(41)+K(68)*Y(42)+K(72)*Y(43)+K(76)*Y(44)+K(80)*Y(45) GIONEUT  1724
     1+K(84)*Y(51)+K(87)*Y(52)+K(90)*Y(53)+K(92)*Y(48)+K(94)*Y(49)+K(110 GIONEUT  1725
     1)+K(111)*Y(7)+K(112)*Y(19)+K(184)*Y(18))                           GIONEUT  1726
      FARM=(+K(115)*Y(38)*Y(7)+K(182)*Y(33)*Y(25))                       GIONEUT  1727
      GO TO 100                                                          GIONEUT  1728
  315 38 CONTINUE                                                        GIONEUT  1729
      RMOV=(+K(69)*Y(42)+K(73)*Y(43)+K(77)*Y(44)+K(81)*Y(45)+K(93)*Y(48) GIONEUT  1730
     1+K(95)*Y(49)+K(113)+K(114)+K(115)*Y(7)+K(116)*Y(9)+K(117)*Y(18))   GIONEUT  1731
      FARM=(Y(25)*(+K(109)*Y(34)+K(181)*Y(32)*Y(8)))                     GIONEUT  1732
      GO TO 100                                                          GIONEUT  1733
  320 39 CONTINUE                                                        GIONEUT  1734
      RMOV=(+K(36)*Y(7)+K(37)*Y(13)+K(163)*Y(57)+K(164)*Y(20))           GIONEUT  1735
      FARM=(+K(162)*Y(4)*Y(8)*Y(57))                                     GIONEUT  1736
      GO TO 100                                                          GIONEUT  1737
   40 CONTINUE                                                           GIONEUT  1738
  325 RMOV=(+K(50)*Y(18)+K(156)*Y(30))                                   GIONEUT  1739
      FARM=(+K(35)*Y(4)*Y(19))                                           GIONEUT  1740
      GO TO 100                                                          GIONEUT  1741
   41 CONTINUE                                                           GIONEUT  1742
      RMOV=(+K(24)*Y(30)+K(62)*Y(35)+K(63)*Y(36)+K(64)*Y(37)+K(170)*Y(13 GIONEUT  1743
  330 1)*Y(57)+K(178)*Y(23)*Y(23))                                       GIONEUT  1744
      FARM=(+K(54)*Y(50)*Y(13))                                          GIONEUT  1745
      GO TO 100                                                          GIONEUT  1746
   42 CONTINUE                                                           GIONEUT  1747
      RMOV=(Y(57)*(+K(51)*Y(25)+K(172)*Y(13))+K(25)*Y(30)+K(65)*Y(32)+K( GIONEUT  1748
  335 166)*Y(35)+K(67)*Y(36)+K(68)*Y(37)+K(69)*Y(38))                    GIONEUT  1749
      FARM=(Y(13)*(+K(60)*Y(48)+K(61)*Y(47)+K(170)*Y(41)*Y(57))+K(174)*Y GIONEUT  1750
     1(43)*Y(57))                                                        GIONEUT  1751
      GO TO 100                                                          GIONEUT  1752
   43 CONTINUE                                                           GIONEUT  1753
  340 RMOV=(Y(57)*(+K(173)*Y(13)+K(174))+K(26)*Y(30)+K(70)*Y(35)+K(71)*Y GIONEUT  1754
     1(36)+K(72)*Y(37)+K(73)*Y(38))                                      GIONEUT  1755
      FARM=(Y(13)*(+K(55)*Y(53)+K(59)*Y(49)+K(172)*Y(42)*Y(57))+K(175)*Y GIONEUT  1756
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     1(44)*Y(57))                                                                    GIONEUT  1757
       GO TO 100                                                                     GIONEUT  1758
345  44 CONTINUE                                                                     GIONEUT  1759
       RMOV=(Y(57)*(+K(52)*Y(13)+K(175))+K(27)*Y(30)+K(74)*Y(35)+K(75)*Y(          GIONEUT  1760
     136)+K(76)*Y(37)+K(77)*Y(38))                                                 GIONEUT  1761
       FARM=(Y(57)*(+K(173)*Y(43)*Y(13)+K(176)*Y(45)))                             GIONEUT  1762
       GO TO 100                                                                   GIONEUT  1763
350  45 CONTINUE                                                                   GIONEUT  1764
       RMOV=(+K(28)*Y(30)+K(78)*Y(35)+K(79)*Y(36)+K(80)*Y(37)+K(81)*Y(38)          GIONEUT  1765
     1+K(176)*Y(57))                                                               GIONEUT  1766
       FARM=(+K(52)*Y(44)*Y(13)*Y(57))                                             GIONEUT  1767
       GO TO 100                                                                   GIONEUT  1768
355  46 CONTINUE                                                                   GIONEUT  1769
       RMOV=(+K(57)*Y(25))                                                         GIONEUT  1770
       FARM=(+K(171)*Y(41)*Y(23)*Y(23))                                            GIONEUT  1771
       GO TO 100                                                                   GIONEUT  1772
     47 CONTINUE                                                                   GIONEUT  1773
360    RMOV=(+K(29)*Y(30)+K(61)*Y(13))                                             GIONEUT  1774
       FARM=(+K(53)*Y(50)*Y(13))                                                   GIONEUT  1775
       GO TO 100                                                                   GIONEUT  1776
     48 CONTINUE                                                                   GIONEUT  1777
       RMOV=(Y(13)*(+K(58)*Y(23)+K(60))+K(91)*Y(36)+K(92)*Y(37)+K(93)*Y(3          GIONEUT  1778
365  18))                                                                          GIONEUT  1779
       FARM=(+K(57)*Y(46)*Y(25))                                                   GIONEUT  1780
       GO TO 100                                                                   GIONEUT  1781
     49 CONTINUE                                                                   GIONEUT  1782
       RMOV=(+K(30)*Y(30)+K(59)*Y(13)+K(94)*Y(37)+K(95)*Y(38))                     GIONEUT  1783
370    FARM=(+K(51)*Y(42)*Y(25)*Y(57)+K(58)*Y(48)*Y(13)*Y(23))                     GIONEUT  1784
       GO TO 100                                                                   GIONEUT  1785
     50 CONTINUE                                                                   GIONEUT  1786
       RMOV=(+K(53)*Y(13)+K(54)*Y(13))                                             GIONEUT  1787
       FARM=(+K(37)*Y(39)*Y(13))                                                   GIONEUT  1788
375    GO TO 100                                                                   GIONEUT  1789
     51 CONTINUE                                                                   GIONEUT  1790
       RMOV=(+K(82)*Y(35)+K(83)*Y(36)+K(84)*Y(37)+K(157)*Y(30)+K(177)*Y(1          GIONEUT  1791
     13)*Y(57))                                                                    GIONEUT  1792
       FARM=(Y(13)*(+K(56)*Y(54)+K(166)*Y(5)*Y(57)))                               GIONEUT  1793
380    GO TO 100                                                                   GIONEUT  1794
     52 CONTINUE                                                                   GIONEUT  1795
       RMOV=(+K(85)*Y(35)+K(86)*Y(36)+K(87)*Y(37)+K(158)*Y(30)+K(178)*Y(1          GIONEUT  1796
     13)*Y(57))                                                                    GIONEUT  1797
       FARM=(+K(177)*Y(51)*Y(13)*Y(57))                                            GIONEUT  1798
385    GO TO 100                                                                   GIONEUT  1799
     53 CONTINUE                                                                   GIONEUT  1800
       RMOV=(+K(55)*Y(13)+K(88)*Y(35)+K(89)*Y(36)+K(90)*Y(37)+K(159)*Y(30          GIONEUT  1801
     1))                                                                           GIONEUT  1802
       FARM=(+K(178)*Y(52)*Y(13)*Y(57))                                            GIONEUT  1803
390    GO TO 100                                                                   GIONEUT  1804
     54 CONTINUE                                                                   GIONEUT  1805
       RMOV=(+K(56)*Y(13))                                                         GIONEUT  1806
       FARM=(+K(165)*Y(5)*Y(25)*Y(23))                                             GIONEUT  1807
       GO TO 100                                                                   GIONEUT  1808
395  55 CONTINUE                                                                   GIONEUT  1809
       RMOV=(+K(20)*Y(7)+K(21)*Y(10)+K(202))                                       GIONEUT  1810
       FARM=(+K(55)*Y(53)*Y(13)+K(91)*Y(48)*Y(36))                                 GIONEUT  1811
       GO TO 100                                                                   GIONEUT  1812
     56 CONTINUE                                                                   GIONEUT  1813
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400                 RMOV=(+K(122)*Y(18)+K(205))                    GIONEUT  1814
                    FARM=(+K(123)*Y(36))                           GIONEUT  1815
          100       FORM(IALT)=FARM                                GIONEUT  1816
                    REMV(IALT)=RMOV                                GIONEUT  1817
                    RETURN                                         GIONEUT  1818
405                 END                                            GIONEUT  1819
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      SUBROUTINE RATECN(IALT)                                          GIONEUT  1820
C                                                                      GIONEUT  1821
C  THIS SUBROUTINE COMPUTES THE IONIZATION RATES.  ON THE INITIAL      GIONEUT  1822
C  ENTRY IT COMPUTES AND SAVES H*F AT NOON FOR O2, N2, AND O.          GIONEUT  1823
C                                                                      GIONEUT  1824
      DIMENSION SX(6),QE(6),EX(6),PHI(16),SIGI(16),SIGEFF(16)          GIONEUT  1825
      DIMENSION DISOC(14),XIN(8),YIN(8),ZS(8),CHIS(4)                  GIONEUT  1826
C                                                                      GIONEUT  1827
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)    GIONEUT  1828
C                                                                      GIONEUT  1829
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                 GIONEUT  1830
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)   GIONEUT  1831
C                                                                      GIONEUT  1832
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,     GIONEUT  1833
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                        GIONEUT  1834
C                                                                      GIONEUT  1835
      COMMON/IONS/WAVE(88),FLUX(88),SIGMA(9,88),R(8,4,8)               GIONEUT  1836
C                                                                      GIONEUT  1837
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON         GIONEUT  1838
C                                                                      GIONEUT  1839
      COMMON/RATECON/AK(88),BK(88),CK(88),DK(215),CYMB(6,215)          GIONEUT  1840
C                                                                      GIONEUT  1841
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)   GIONEUT  1842
C                                                                      GIONEUT  1843
      COMMON/LOGIC/NIGHT,DAY,JLOOK,RESET,END                           GIONEUT  1844
C                                                                      GIONEUT  1845
      COMMON/COLUM/O2COL,O3COL,DIS(19,59)                              GIONEUT  1846
C                                                                      GIONEUT  1847
      REAL N2NOON,N,MASS,LYALFA,LYBETA                                 GIONEUT  1848
C                                                                      GIONEUT  1849
      COMMON/ALTITUD/ZBOT,ZTOP,TURB,ZTRANS                             GIONEUT  1850
C                                                                      GIONEUT  1851
      LOGICAL NIGHT,DAY,JLOOK                                          GIONEUT  1852
C                                                                      GIONEUT  1853
C  THE FOLLOWING THREE DATA STATMENTS CONTAIN THE SOLAR FLUX (X10-9)   GIONEUT  1854
C  THE IONIZATION CROSS SECTIONS AND THE EFFECTIVE ABSORPTION CROSS    GIONEUT  1855
C  SECTIONS (X10+18) FOR O2(1DG).                                      GIONEUT  1856
C                                                                      GIONEUT  1857
      DATA PHI/0.123,0.202,0.18,0.06,0.16,0.208,0.432,0.092,0.626,0.59,GIONEUT  1858
     1         0.08,0.08,0.11,1.63,2.29,0.13/                          GIONEUT  1859
C                                                                      GIONEUT  1860
      DATA SIGI/2.0,3.0,4.0,3.6,4.0,10.0,4.0,4.0,5.0,3.0,5.0,5.0,3.8,  GIONEUT  1861
     1          5.5,5.0,5.0/                                          GIONEUT  1862
C                                                                      GIONEUT  1863
      DATA SIGEFF/0.186,0.186,0.04,0.021,1.0,0.1,1.0,0.12,1.0,2.0,0.4, GIONEUT  1864
     1            0.7,0.2,1.15,1.12,1.0/                             GIONEUT  1865
C                                                                      GIONEUT  1866
C  THE FOLLOWING TWO DATA STATMENTS CONTAIN THE ALTITUDES AND THE      GIONEUT  1867
C  SOLAR ZENITH ANGLE ARRAYS CORRESPONDING TO THE INPUT ARRAYS OF      GIONEUT  1868
C  THE RATE COEFFICIENTS FOR THE ENERGETIC ELECTRONS.                  GIONEUT  1869
C                                                                      GIONEUT  1870
      DATA ZS/95.,100.,130.,170.,210.,250.,300.,400./                  GIONEUT  1871
C                                                                      GIONEUT  1872
      DATA CHIS/49.77,61.50,76.22,109.7976/                            GIONEUT  1873
C                                                                      GIONEUT  1874
      DATA COSMIC/1.0E-17/                                             GIONEUT  1875
      DATA IPASS/1/                                                    GIONEUT  1876
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      C
            GRAVCOR(ZZ)=1.0/((1.0+ZZ/RADIUS)**2)                          GIONEUT 1877
                                                                          GIONEUT 1878
   60 C                                                                   GIONEUT 1879
            T1=TEMP(IALT)                                                 GIONEUT 1880
            ZZ=Z(IALT)                                                    GIONEUT 1881
            T2=T1/300.                                                    GIONEUT 1882
            O2COL=0.                                                      GIONEUT 1883
   65       O3COL=0.                                                      GIONEUT 1884
            DO 1 J=1,NREAC2                                               GIONEUT 1885
            A1=AK(J)                                                      GIONEUT 1886
            B1=BK(J)                                                      GIONEUT 1887
            C1=CK(J)                                                      GIONEUT 1888
   70       IF(B1 .NE. 0.) A1=A1*(T2**B1)                                 GIONEUT 1889
            IF(C1 .NE. 0.) A1=A1*EXP(C1/T1)                               GIONEUT 1890
            DK(J+NREAC)=A1                                                GIONEUT 1891
      1     CONTINUE                                                      GIONEUT 1892
            IF(IPASS .NE. 1) GO TO 30                                     GIONEUT 1893
   75       DO 26 L=1,16                                                  GIONEUT 1894
            PHI(L)=PHI(L)*1.0E+09                                         GIONEUT 1895
            SIGI(L)=SIGI(L)*1.0E-18                                       GIONEUT 1896
            SIGEFF(L)=SIGEFF(L)*1.0E-18                                   GIONEUT 1897
      26    CONTINUE                                                      GIONEUT 1898
   80       IPASS=2                                                       GIONEUT 1899
            DO 5 L=1,8                                                    GIONEUT 1900
            DO 5 I=1,4                                                    GIONEUT 1901
            DO 5 J=1,8                                                    GIONEUT 1902
            IF(R(J,I,L) .EQ. 0.) GO TO 3                                  GIONEUT 1903
   85       R(J,I,L)=ALOG(R(J,I,L))                                       GIONEUT 1904
            GO TO 5                                                       GIONEUT 1905
      3     R(J,I,L)=-300.                                                GIONEUT 1906
      5     CONTINUE                                                      GIONEUT 1907
      C                                                                   GIONEUT 1908
   90 C  SAVE H*F AT NOONTIME FOR O2, O, AND N2.                          GIONEUT 1909
      C                                                                   GIONEUT 1910
      30    GRAVTY=GRAV*GRAVCOR(ZZ)                                       GIONEUT 1911
            T=BOLTZ*TEMP(IALT)/GRAVTY                                     GIONEUT 1912
            DO 20 I=1,3                                                   GIONEUT 1913
   95       IF(I .EQ. 1) F(I)=MASS(8)                                     GIONEUT 1914
            IF(I .EQ. 2) F(I)=MASS(23)                                    GIONEUT 1915
            IF(I .EQ. 3) F(I)=MASS(7)                                     GIONEUT 1916
            SCALE=T/F(I)                                                  GIONEUT 1917
            CALL CHAPMAN(CXINOON,ZZ,RADIUS,SCALE,APPROX)                  GIONEUT 1918
  100       PR=SCALE*APPROX                                               GIONEUT 1919
            IF(I .EQ. 1) O2NOON=PR                                        GIONEUT 1920
            IF(I .EQ. 2) N2NOON=PR                                        GIONEUT 1921
            IF(I .EQ. 3) ONOON=PR                                         GIONEUT 1922
      20    CONTINUE                                                      GIONEUT 1923
  105       IF(NIGHT) GO TO 95                                            GIONEUT 1924
            IF(DAY  ) GO TO 10                                            GIONEUT 1925
            IF(ZZ .LT. ZTRANS) GO TO 11                                   GIONEUT 1926
      C                                                                   GIONEUT 1927
      C  GO GET PHOTODISSOCIATION RATE COEFFICIENTS.                      GIONEUT 1928
  110 C                                                                   GIONEUT 1929
      10    CALL DISSOC(DISOC,IALT)                                       GIONEUT 1930
            DK(192)=DISOC(2)                                              GIONEUT 1931
            DK(193)=DISOC(1)                                              GIONEUT 1932
            DK(194)=DISOC(6)                                              GIONEUT 1933
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      DK(195)=DISOC(5)                                                  GIONEUT 1934
      DK(196)=DISOC(3)                                                  GIONEUT 1935
      DK(197)=DISOC(4)                                                  GIONEUT 1936
      DK(198)=DISOC(12)                                                 GIONEUT 1937
      DK(199)=DISOC(13)                                                 GIONEUT 1938
      DK(200)=DISOC(7)                                                  GIONEUT 1939
      DK(201)=DISOC(8)                                                  GIONEUT 1940
      DK(202)=DISOC(9)                                                  GIONEUT 1941
      DK(203)=DISOC(10)                                                 GIONEUT 1942
      DK(204)=DISOC(11)                                                 GIONEUT 1943
      DK(205)=DISOC(14)                                                 GIONEUT 1944
11    IF(.NOT. JLOOK) GO TO 52                                          GIONEUT 1945
      IF(IALT .EQ. 1) GO TO 35                                          GIONEUT 1946
      IF(IALT .EQ. K) GO TO 40                                          GIONEUT 1947
      IF(MOD(IALT-1,12) .NE. 0) GO TO 52                                GIONEUT 1948
35    IA=IALT/12+1                                                      GIONEUT 1949
      GO TO 45                                                          GIONEUT 1950
40    IA=IALT/12+2                                                      GIONEUT 1951
45    DO 50 J=1,14                                                      GIONEUT 1952
      DIS(J,IA)=DK(J+191)                                               GIONEUT 1953
50    CONTINUE                                                          GIONEUT 1954
      DIS(15,IA)=Z(IALT)                                                GIONEUT 1955
      DIS(16,IA)=N(IALT,8)                                              GIONEUT 1956
      DIS(17,IA)=O2COL                                                  GIONEUT 1957
      DIS(18,IA)=N(IALT,9)                                              GIONEUT 1958
      DIS(19,IA)=O3COL                                                  GIONEUT 1959
52    IF(ZZ .LT. ZTRANS) GO TO 95                                       GIONEUT 1960
C                                                                       GIONEUT 1961
C  COMPUTE RATE COEFFICIENTS FOR ENERGETIC ELECTRON REACTIONS.          GIONEUT 1962
C                                                                       GIONEUT 1963
      IF(ZZ .LT. ZS(1)) GO TO 280                                       GIONEUT 1964
      DO 200 I=1,4                                                      GIONEUT 1965
      IF(SCXI .EQ. CHIS(I)) GO TO 240                                   GIONEUT 1966
      IF(SCXI .LT. CHIS(I)) GO TO 210                                   GIONEUT 1967
200   CONTINUE                                                          GIONEUT 1968
210   DO 220 J=1,8                                                      GIONEUT 1969
      IF(ZZ .EQ. ZS(J)) GO TO 270                                       GIONEUT 1970
220   CONTINUE                                                          GIONEUT 1971
      DO 235 L=1,8                                                      GIONEUT 1972
      DO 225 J=1,8                                                      GIONEUT 1973
      XIN(J)=ZS(J)                                                      GIONEUT 1974
      YIN(J)=R(J,I-1,L)                                                 GIONEUT 1975
225   CONTINUE                                                          GIONEUT 1976
      A1=YINT(ZZ,XIN,YIN,0)                                             GIONEUT 1977
      B1=YINT(ZZ,XIN,YIN,8)                                             GIONEUT 1978
      DO 230 J=1,8                                                      GIONEUT 1979
      YIN(J)=R(J,I,L)                                                   GIONEUT 1980
230   CONTINUE                                                          GIONEUT 1981
      A1=YINT(ZZ,XIN,YIN,0)                                             GIONEUT 1982
      C1=YINT(ZZ,XIN,YIN,8)                                             GIONEUT 1983
      A1=(SCXI-CHIS(I-1))/(CHIS(I)-CHIS(I-1))                           GIONEUT 1984
      DK(L+207)=EXP(B1-A1*(B1-C1))                                      GIONEUT 1985
235   CONTINUE                                                          GIONEUT 1986
      GO TO 55                                                          GIONEUT 1987
240   DO 245 J=1,8                                                      GIONEUT 1988
      IF(ZZ .EQ. ZS(J)) GO TO 260                                       GIONEUT 1989
245   CONTINUE                                                          GIONEUT 1990
```

```
                DO 255 L=1,8                                                    GIONEUT  1991
                DO 250 J=1,8                                                    GIONEUT  1992
                XIN(J)=ZS(J)                                                    GIONEUT  1993
175             YIN(J)=R(J,I,L)                                                 GIONEUT  1994
250             CONTINUE                                                        GIONEUT  1995
                A1=YINT(ZZ,XIN,YIN,0)                                           GIONEUT  1996
                DK(L+207)=EXP(YINT(ZZ,XIN,YIN,8))                               GIONEUT  1997
255             CONTINUE                                                        GIONEUT  1998
180             GO TO 55                                                        GIONEUT  1999
260             DO 265 L=1,8                                                    GIONEUT  2000
                DK(L+207)=EXP(R(J,I,L))                                         GIONEUT  2001
265             CONTINUE                                                        GIONEUT  2002
                GO TO 55                                                        GIONEUT  2003
185     270     DO 275 L=1,8                                                    GIONEUT  2004
                A1=(SCXI-CHIS(I-1))/(CHIS(I)-CHIS(I-1))                         GIONEUT  2005
                DK(L+207)=EXP(R(J,I-1,L)-A1*(R(J,I-1,L)-R(J,I,L)))              GIONEUT  2006
275             CONTINUE                                                        GIONEUT  2007
                GO TO 55                                                        GIONEUT  2008
190     280     DO 285 L=1,8                                                    GIONEUT  2009
                DK(L+207)=0.                                                    GIONEUT  2010
285             CONTINUE                                                        GIONEUT  2011
C                                                                               GIONEUT  2012
C  COMPUTE N*H*F FOR O2, N2, AND O AT SOLAR ZENITH ANGLE CXI.                   GIONEUT  2013
195 C                                                                           GIONEUT  2014
55      GRAVTY=GRAV*GRAVCOR(ZZ)                                                 GIONEUT  2015
        T=BOLTZ*TEMP(IALT)/GRAVTY                                               GIONEUT  2016
        DO 60 I=1,3                                                             GIONEUT  2017
        SCALE=T/F(I)                                                            GIONEUT  2018
200     CALL CHAPMAN(CXI,ZZ,RADIUS,SCALE,APPROX)                                GIONEUT  2019
        IF(I .EQ. 1) E(I)=N(IALT,8)                                             GIONEUT  2020
        IF(I .EQ. 2) E(I)=N(IALT,23)                                            GIONEUT  2021
        IF(I .EQ. 3) E(I)=N(IALT,7)                                             GIONEUT  2022
        EX(I)=E(I)*SCALE*APPROX                                                 GIONEUT  2023
205 60  CONTINUE                                                                GIONEUT  2024
C                                                                               GIONEUT  2025
C  COMPUTE THE ATTENUATED FLUX AT EACH WAVELENGTH.                              GIONEUT  2026
C  SEPARATE THE EUV AND X RAY FLUXES.                                           GIONEUT  2027
C                                                                               GIONEUT  2028
210     DO 65 I=1,6                                                             GIONEUT  2029
        QE(I)=0.                                                                GIONEUT  2030
        SX(I)=0.                                                                GIONEUT  2031
65      CONTINUE                                                                GIONEUT  2032
        DO 90 L=1,88                                                            GIONEUT  2033
215     ABS=0.                                                                  GIONEUT  2034
        DO 70 I=1,3                                                             GIONEUT  2035
        ABS=ABS+SIGMA(I,L)*EX(I)                                                GIONEUT  2036
70      CONTINUE                                                                GIONEUT  2037
        AFLUX=0.                                                                GIONEUT  2038
220     IF(ABS .GT. 650.) GO TO 71                                              GIONEUT  2039
        AFLUX=FLUX(L)*EXP(-ABS)                                                 GIONEUT  2040
C                                                                               GIONEUT  2041
C  COMPUTE THE IONIZATION COEFFICIENTS,  SKIP LYMAN ALPHA LINE.                 GIONEUT  2042
C                                                                               GIONEUT  2043
225 71  IF(L .EQ. 1) GO TO 86                                                   GIONEUT  2044
        IF(L .GE. 74) GO TO 80                                                  GIONEUT  2045
        DO 75 I=1,6                                                             GIONEUT  2046
        QE(I)=QE(I)+SIGMA(I+3,L)*AFLUX                                          GIONEUT  2047
```

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   75    CONTINUE                                                          GIONEUT  2048
230      GO TO 90                                                          GIONEUT  2049
   80    DO 85 I=1,6                                                       GIONEUT  2050
         SX(I)=SX(I)+SIGMA(I+3,L)*AFLUX                                    GIONEUT  2051
   85    CONTINUE                                                          GIONEUT  2052
         GO TO 90                                                          GIONEUT  2053
235   86  SFLUX=AFLUX                                                       GIONEUT  2054
   90    CONTINUE                                                          GIONEUT  2055
C                                                                          GIONEUT  2056
C  PARTITION THE X-RAY IONIZATION ACCORDING TO SWIDER, REVIEWS OF          GIONEUT  2057
C  GEOPHYSICS, 7, PG 573, 1969.                                            GIONEUT  2058
240 C                                                                      GIONEUT  2059
      AX=N(IALT,8)+0.5*N(IALT,7)                                           GIONEUT  2060
      BX=1.0/(1.0+(N(IALT,23)/(1.15*AX)))                                  GIONEUT  2061
      CX=0.71*N(IALT,8)/AX                                                 GIONEUT  2062
      XTOTAL=SX(1)*N(IALT,8)+SX(2)*N(IALT,23)+SX(3)*N(IALT,7)              GIONEUT  2063
245  1       +SX(4)*N(IALT,11)+SX(5)*N(IALT,21)+SX(6)*N(IALT,16)           GIONEUT  2064
      SX(1)=BX*CX*XTOTAL                                                   GIONEUT  2065
      SX(2)=0.61*(1.0-BX)*XTOTAL                                           GIONEUT  2066
      SX(3)=(1.0-CX)*BX*XTOTAL                                             GIONEUT  2067
      SX(6)=0.19*(1.0-BX)*XTOTAL                                           GIONEUT  2068
250 C                                                                      GIONEUT  2069
C  COMPUTE TOTAL EUV AND X-RAY IONIZATION RATE COEFFICIENT FOR EACH ION.   GIONEUT  2070
C                                                                          GIONEUT  2071
      DK(185)=QE(3)+SX(3)/N(IALT,7)                                        GIONEUT  2072
      DK(186)=QE(1)+SX(1)/N(IALT,8)                                        GIONEUT  2073
255   DK(187)=QE(2)+SX(2)/N(IALT,23)                                       GIONEUT  2074
      DK(189)=QE(6)+SX(6)/N(IALT,16)                                       GIONEUT  2075
      DK(190)=QE(4)+SX(4)                                                  GIONEUT  2076
      DK(191)=QE(5)+SX(5)                                                  GIONEUT  2077
C                                                                          GIONEUT  2078
260 C  COMPUTE IONIZATION RATE COEFFICIENT FOR NO BY LYMAN ALPHA.          GIONEUT  2079
C                                                                          GIONEUT  2080
      DK(188)=2.08E-18*SFLUX                                               GIONEUT  2081
C                                                                          GIONEUT  2082
C  COMPUTE IONIZATION RATE COEFFICIENT FOR O2(1DG) FOR WAVELENGTHS         GIONEUT  2083
265 C  1027-1117 A.                                                        GIONEUT  2084
C                                                                          GIONEUT  2085
      DO 92 L=1,16                                                         GIONEUT  2086
      SFLUX=SIGEFF(L)*EX(1)                                                GIONEUT  2087
      IF(SFLUX .GT. 650.) GO TO 92                                         GIONEUT  2088
270   DK(207)=DK(207)+PHI(L)*SIGI(L)*EXP(-SFLUX)                           GIONEUT  2089
   92 CONTINUE                                                             GIONEUT  2090
C                                                                          GIONEUT  2091
C  ADD CONTRIBUTIONS FROM SCATTERED RADIATIONS AT LYMAN ALPHA,             GIONEUT  2092
C  LYMAN BETA, HE(I)(584A), AND HE(II)(304A).                              GIONEUT  2093
275 C                                                                      GIONEUT  2094
   95 AA=N(IALT,8)*O2NOON                                                  GIONEUT  2095
      AB=N(IALT,23)*N2NOON                                                 GIONEUT  2096
      AC=N(IALT,7)*ONOON                                                   GIONEUT  2097
      POWER=AA*SIGMA(1,1)                                                  GIONEUT  2098
280   EXPON=0.                                                             GIONEUT  2099
      IF(POWER .GT. 650.) GO TO 91                                         GIONEUT  2100
      EXPON=EXP(-POWER)                                                    GIONEUT  2101
   91 LYALFA=1.0E-02*2.68E-18*FLUX(1)*EXPON                                GIONEUT  2102
      POWER=AA*SIGMA(1,2)+AB*SIGMA(2,2)                                    GIONEUT  2103
285   EXPON=0.                                                             GIONEUT  2104
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```
      R(1)=K(1)*Y(7)*Y(17)                                              GIONEUT  2595
      R(2)=K(2)*Y(7)*Y(10)                                              GIONEUT  2596
   60 R(3)=K(3)*Y(7)*Y(12)                                              GIONEUT  2597
      R(4)=K(4)*Y(7)*Y(19)                                              GIONEUT  2598
      R(5)=K(5)*Y(11)*Y(12)                                             GIONEUT  2599
      R(6)=K(6)*Y(11)*Y(12)                                             GIONEUT  2600
      R(7)=K(7)*Y(11)*Y(9)                                              GIONEUT  2601
   65 R(8)=K(8)*Y(16)*Y(9)                                              GIONEUT  2602
      R(9)=K(9)*Y(16)*Y(19)                                             GIONEUT  2603
      R(10)=K(10)*Y(16)*Y(19)                                           GIONEUT  2604
      R(11)=K(11)*Y(16)*Y(19)                                           GIONEUT  2605
      R(12)=K(12)*Y(10)*Y(10)                                           GIONEUT  2606
   70 R(13)=K(13)*Y(10)*Y(12)                                           GIONEUT  2607
      R(14)=K(14)*Y(17)*Y(8)                                            GIONEUT  2608
      R(15)=K(15)*Y(27)*Y(13)                                           GIONEUT  2609
      R(16)=K(16)*Y(27)*Y(57)                                           GIONEUT  2610
      R(17)=K(17)*Y(27)*Y(15)                                           GIONEUT  2611
   75 R(18)=K(18)*Y(20)*Y(57)                                           GIONEUT  2612
      R(19)=K(19)*Y(20)                                                 GIONEUT  2613
      R(20)=K(20)*Y(55)*Y(7)                                            GIONEUT  2614
      R(21)=K(21)*Y(55)*Y(10)                                           GIONEUT  2615
      R(22)=K(22)*Y(28)*Y(30)                                           GIONEUT  2616
   80 R(23)=K(23)*Y(28)*Y(30)                                           GIONEUT  2617
      R(24)=K(24)*Y(41)*Y(30)                                           GIONEUT  2618
      R(25)=K(25)*Y(42)*Y(30)                                           GIONEUT  2619
      R(26)=K(26)*Y(43)*Y(30)                                           GIONEUT  2620
      R(27)=K(27)*Y(44)*Y(30)                                           GIONEUT  2621
   85 R(28)=K(28)*Y(45)*Y(30)                                           GIONEUT  2622
      R(29)=K(29)*Y(47)*Y(30)                                           GIONEUT  2623
      R(30)=K(30)*Y(49)*Y(30)                                           GIONEUT  2624
      R(31)=K(31)*Y(7)*Y(30)                                            GIONEUT  2625
      R(32)=K(32)*Y(8)*Y(23)*Y(30)                                      GIONEUT  2626
   90 R(33)=K(33)*Y(4)*Y(18)                                            GIONEUT  2627
      R(34)=K(34)*Y(4)*Y(16)                                            GIONEUT  2628
      R(35)=K(35)*Y(4)*Y(19)                                            GIONEUT  2629
      R(36)=K(36)*Y(39)*Y(7)                                            GIONEUT  2630
      R(37)=K(37)*Y(39)*Y(13)                                           GIONEUT  2631
   95 R(38)=K(38)*Y(28)*Y(7)                                            GIONEUT  2632
      R(39)=K(39)*Y(28)*Y(7)                                            GIONEUT  2633
      R(40)=K(40)*Y(3)*Y(11)                                            GIONEUT  2634
      R(41)=K(41)*Y(1)*Y(7)                                             GIONEUT  2635
      R(42)=K(42)*Y(6)*Y(8)                                             GIONEUT  2636
  100 R(43)=K(43)*Y(6)*Y(8)                                             GIONEUT  2637
      R(44)=K(44)*Y(6)*Y(8)                                             GIONEUT  2638
      R(45)=K(45)*Y(2)*Y(8)                                             GIONEUT  2639
      R(46)=K(46)*Y(2)*Y(8)                                             GIONEUT  2640
      R(47)=K(47)*Y(2)*Y(23)                                            GIONEUT  2641
  105 R(48)=K(48)*Y(2)*Y(23)                                            GIONEUT  2642
      R(49)=K(49)*Y(2)*Y(18)                                            GIONEUT  2643
      R(50)=K(50)*Y(40)*Y(18)                                           GIONEUT  2644
      R(51)=K(51)*Y(42)*Y(25)*Y(57)                                     GIONEUT  2645
      R(52)=K(52)*Y(44)*Y(13)*Y(57)                                     GIONEUT  2646
  110 R(53)=K(53)*Y(50)*Y(13)                                           GIONEUT  2647
      R(54)=K(54)*Y(50)*Y(13)                                           GIONEUT  2648
      R(55)=K(55)*Y(53)*Y(13)                                           GIONEUT  2649
      R(56)=K(56)*Y(54)*Y(13)                                           GIONEUT  2650
      R(57)=K(57)*Y(46)*Y(25)                                           GIONEUT  2651
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```
      SUBROUTINE CHEMPR(IZ)                                                 GIONEUT  2538
C                                                                           GIONEUT  2539
C  THIS SUBROUTINE PRINTS OUT THE FULL CHEMISTRY LIST ALONG WITH            GIONEUT  2540
C  THE RATE COEFFICIENTS AND THE RATES OF ALL REACTIONS AT THE              GIONEUT  2541
C  ALTITUDE CORRESPONDING TO THE INDEX IZ.                                  GIONEUT  2542
C                                                                           GIONEUT  2543
C                                                                           GIONEUT  2544
      DIMENSION Y(57),R(215),K(215)                                         GIONEUT  2545
C                                                                           GIONEUT  2546
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)         GIONEUT  2547
C                                                                           GIONEUT  2548
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                      GIONEUT  2549
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)        GIONEUT  2550
C                                                                           GIONEUT  2551
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS ISPECI,KSPECI,NREAC,KTOP,       GIONEUT  2552
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                            GIONEUT  2553
C                                                                           GIONEUT  2554
      COMMON/ESM/OLDN(692,30),OLDCON(424,26),OLDU(692,26),RATES(88,692)     GIONEUT  2555
C                                                                           GIONEUT  2556
      COMMON/LOGIC/NIGHT,DAY,JLOOK,RESET,END                                GIONEUT  2557
C                                                                           GIONEUT  2558
      COMMON/RATECON/AK(88),BK(88),CK(88),DK(215),CYMB(6,215)               GIONEUT  2559
C                                                                           GIONEUT  2560
      LEVEL 3, OLDN,OLDCON,OLDU,RATES                                       GIONEUT  2561
      REAL K,N,NZERO                                                        GIONEUT  2562
      LOGICAL NIGHT                                                         GIONEUT  2563
      EQUIVALENCE (Y,E),(R,F),(NZERO,K)                                     GIONEUT  2564
C                                                                           GIONEUT  2565
      WRITE(6,1) Z(IZ),SCXI                                                 GIONEUT  2566
    1 FORMAT(1H1,"  CHEMISTRY AT ",F7.2," KM. AND AT",      1PE12.5         GIONEUT  2567
     1"DEGREES.")                                                           GIONEUT  2568
      WRITE(6,5)                                                            GIONEUT  2569
    5 FORMAT(1H0,18X,*CHEMICAL REACTION*,35X,*RATE CONSTANT*,5X,            GIONEUT  2570
     1*FORWARD RATE(/CM3/SEC)*)                                             GIONEUT  2571
      DO 6 I=1,NREAC                                                        GIONEUT  2572
      K(I)=DK(I)                                                            GIONEUT  2573
    6 CONTINUE                                                              GIONEUT  2574
      IF(.NOT. NIGHT) GO TO 10                                              GIONEUT  2575
      K(96)=K(99)=K(104)=K(105)=K(110)=0.                                   GIONEUT  2576
      K(113)=K(114)=K(118)=K(120)=K(123)=0.                                 GIONEUT  2577
   10 CALL MOVLEV(RATES(1,IZ),K(128),88)                                    GIONEUT  2578
      IF(IZ .LE. K2) GO TO 11                                               GIONEUT  2579
      K(31)=K(32)=K(35)=0.                                                  GIONEUT  2580
      K(160)=K(161)=K(162)=K(165)=K(166)=0.                                 GIONEUT  2581
   11 DO 25 I=1,ISPECI                                                      GIONEUT  2582
      IF(I .GT. 30) GO TO 4                                                 GIONEUT  2583
      Y(I)=N(IZ,I)                                                          GIONEUT  2584
      GO TO 25                                                              GIONEUT  2585
    4 IF(IZ .GT. K2) GO TO 15                                               GIONEUT  2586
      Y(I)=CONC(IZ,I-30)                                                    GIONEUT  2587
      GO TO 25                                                              GIONEUT  2588
   15 Y(I)=0.                                                               GIONEUT  2589
   25 CONTINUE                                                              GIONEUT  2590
      Y(57)=0.                                                              GIONEUT  2591
      DO 30 I=1,ISPECI                                                      GIONEUT  2592
      Y(57)=Y(57)+Y(I)                                                      GIONEUT  2593
   30 CONTINUE                                                              GIONEUT  2594
```

```
      SUBROUTINE INDEX(COL,LIM,I,DEL)                                   GIONEUT  2509
C                                                                       GIONEUT  2510
C  THIS SUBROUTINE COMPUTES AN INDEX I AND AN INCREMENT DEL FROM        GIONEUT  2511
C  THE COLUMN DENSITY COL.                                              GIONEUT  2512
C                                                                       GIONEUT  2513
      REAL LOG2,LOG5                                                    GIONEUT  2514
      LOGICAL ISKIP                                                     GIONEUT  2515
      DATA ISKIP/.FALSE./                                               GIONEUT  2516
C                                                                       GIONEUT  2517
      IF(ISKIP) GO TO 5                                                 GIONEUT  2518
      LOG2=ALOG10(2.0)                                                  GIONEUT  2519
      LOG5=ALOG10(5.0)                                                  GIONEUT  2520
      ISKIP=.TRUE.                                                      GIONEUT  2521
C                                                                       GIONEUT  2522
5     A=ALOG10(COL)                                                     GIONEUT  2523
      INTA=INT(A)                                                       GIONEUT  2524
      FA=A-INTA                                                         GIONEUT  2525
      I=3*(INTA-LIM)+1                                                  GIONEUT  2526
      IF(FA .GT. LOG2) GO TO 10                                         GIONEUT  2527
      DEL=FA/LOG2                                                       GIONEUT  2528
      RETURN                                                            GIONEUT  2529
10    IF(FA .GT. LOG5) GO TO 20                                         GIONEUT  2530
      DEL=(FA-LOG2)/(LOG5-LOG2)                                         GIONEUT  2531
      I=I+1                                                             GIONEUT  2532
      RETURN                                                            GIONEUT  2533
20    DEL=(FA-LOG5)/(1.0-LOG5)                                          GIONEUT  2534
      I=I+2                                                             GIONEUT  2535
      RETURN                                                            GIONEUT  2536
      END                                                               GIONEUT  2537
```

```
      FUNCTION TRPLT1(ARRAY,IO3,DELO3)                                  GIONEUT  2497
C                                                                       GIONEUT  2498
C  THIS FUNCTION INTERPOLATES IN THE ONE DIMENSIONAL PHOTODISSOCIATION  GIONEUT  2499
C  RATE COEFFICIENT TABLES.                                             GIONEUT  2500
C                                                                       GIONEUT  2501
      DIMENSION ARRAY(1)                                                GIONEUT  2502
C                                                                       GIONEUT  2503
      A=ARRAY(IO3)                                                      GIONEUT  2504
      B=ARRAY(IO3+1)                                                    GIONEUT  2505
      TRPLT1=10.0**(A-DELO3*(A-B))                                      GIONEUT  2506
      RETURN                                                            GIONEUT  2507
      END                                                               GIONEUT  2508
```

```
      FUNCTION TRPLT2(ARRAY,N,M,IO2,DELO2,IO3,DELO3)                    GIONEUT  2481
C                                                                       GIONEUT  2482
C  THIS FUNCTION INTERPOLATES IN THE TWO DIMENSIONAL PHOTODISSOCIATION  GIONEUT  2483
C  RATE COEFFICIENT TABLES.                                             GIONEUT  2484
C                                                                       GIONEUT  2485
      DIMENSION ARRAY(N,M)                                              GIONEUT  2486
C                                                                       GIONEUT  2487
      A=ARRAY(IO2,IO3)                                                  GIONEUT  2488
      B=ARRAY(IO2,IO3+1)                                                GIONEUT  2489
      C=ARRAY(IO2+1,IO3)                                                GIONEUT  2490
      D=ARRAY(IO2+1,IO3+1)                                              GIONEUT  2491
      Y1=A-DELO3*(A-B)                                                  GIONEUT  2492
      Y2=C-DELO3*(C-D)                                                  GIONEUT  2493
      TRPLT2=10.0**(Y1-DELO2*(Y1-Y2))                                   GIONEUT  2494
      RETURN                                                            GIONEUT  2495
      END                                                               GIONEUT  2496
```

```
      IF(O2COL .GT. 23.5) GO TO 210                                    GIONEUT 2467
230   DO 200 II=1,12                                                   GIONEUT 2468
      IF(O2COL .LT. O2C(II)) GO TO 215                                 GIONEUT 2469
200   CONTINUE                                                         GIONEUT 2470
      STOP 7                                                           GIONEUT 2471
205   DISOC(13)=10.0**(PNO(1))                                         GIONEUT 2472
235   GO TO 220                                                        GIONEUT 2473
210   DISOC(13)=0.                                                     GIONEUT 2474
      GO TO 220                                                        GIONEUT 2475
215   DELO2=(O2COL-O2C(II-1))/(O2C(II)-O2C(II-1))                      GIONEUT 2476
      DISOC(13)=10.0**(PNO(II-1)-DELO2*(PNO(II-1)-PNO(II)))            GIONEUT 2477
240   220 O2COL=10.0**(O2COL)                                          GIONEUT 2478
      RETURN                                                           GIONEUT 2479
      END                                                              GIONEUT 2480
```

```
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                          GIONEUT  2410
      LIMIT=14                                                       GIONEUT  2411
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                              GIONEUT  2412
      DISOC(9)=TRPLT1(J202,IO3,DELO3)                                GIONEUT  2413
C                                                                    GIONEUT  2414
C  REACTION CO2 + HV = CO + O1D IN DISOC(10)                         GIONEUT  2415
C                                                                    GIONEUT  2416
      O2COL=O2COLM                                                   GIONEUT  2417
      IF(O2COLM .LT. 1.0E+13)  O2COL=1.1E+13                         GIONEUT  2418
      IF(O2COLM .GT. 5.0E+22)  O2COL=5.0E+22                         GIONEUT  2419
      LIMIT=13                                                       GIONEUT  2420
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                              GIONEUT  2421
      O3COL=O3COLM                                                   GIONEUT  2422
      IF(O3COLM .LT. 1.0E+11)  O3COL=1.1E+11                         GIONEUT  2423
      IF(O3COLM .GT. 2.0E+20)  O3COL=2.0E+20                         GIONEUT  2424
      LIMIT=11                                                       GIONEUT  2425
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                              GIONEUT  2426
      DISOC(10)=TRPLT2(J203,30,29,IO2,DELO2,IO3,DELO3)               GIONEUT  2427
C                                                                    GIONEUT  2428
C  REACTION CO2 + HV = CO + O IN DISOC(11)                           GIONEUT  2429
C                                                                    GIONEUT  2430
      O2COL=O2COLM                                                   GIONEUT  2431
      IF(O2COLM .LT. 1.0E+13)  O2COL=1.1E+13                         GIONEUT  2432
      IF(O2COLM .GT. 2.0E+24)  O2COL=2.0E+24                         GIONEUT  2433
      LIMIT=13                                                       GIONEUT  2434
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                              GIONEUT  2435
      O3COL=O3COLM                                                   GIONEUT  2436
      IF(O3COLM .LT. 1.0E+12)  O3COL=1.1E+12                         GIONEUT  2437
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                         GIONEUT  2438
      LIMIT=12                                                       GIONEUT  2439
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                              GIONEUT  2440
      DISOC(11)=TRPLT2(J204,35,28,IO2,DELO2,IO3,DELO3)               GIONEUT  2441
C                                                                    GIONEUT  2442
C  REACTION HO2 + HV = O2 + H IN DISOC(12)                           GIONEUT  2443
C                                                                    GIONEUT  2444
      O2COL=O2COLM                                                   GIONEUT  2445
      IF(O2COLM .LT. 1.0E+17)  O2COL=1.1E+17                         GIONEUT  2446
      IF(O2COLM .GT. 2.0E+25)  O2COL=2.0E+25                         GIONEUT  2447
      LIMIT=17                                                       GIONEUT  2448
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                              GIONEUT  2449
      O3COL=O3COLM                                                   GIONEUT  2450
      IF(O3COLM .LT. 1.0E+12)  O3COL=1.1E+12                         GIONEUT  2451
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                         GIONEUT  2452
      LIMIT=12                                                       GIONEUT  2453
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                              GIONEUT  2454
      DISOC(12)=TRPLT2(J198,26,28,IO2,DELO2,IO3,DELO3)               GIONEUT  2455
C                                                                    GIONEUT  2456
C  REACTION NO3 + HV = NO2 + O2 IN DISOC(14)                         GIONEUT  2457
C                                                                    GIONEUT  2458
      O3COL=O3COLM                                                   GIONEUT  2459
      IF(O3COLM .LT. 1.0E+14)  O3COL=1.1E+14                         GIONEUT  2460
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                         GIONEUT  2461
      LIMIT=14                                                       GIONEUT  2462
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                              GIONEUT  2463
      DISOC(14)=TRPLT1(J205,IO3,DELO3)                               GIONEUT  2464
      O2COL=ALOG10(O2COLM)                                           GIONEUT  2465
      IF(O2COL .LT. 18.0) GO TO 205                                  GIONEUT  2466
```

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      DISOC(4)=TRPLT2(J197,27,28,IO2,DELO2,IO3,DELO3)                    GIONEUT  2353
C                                                                        GIONEUT  2354
C  REACTION O3 + HV = O1D + O21D IN DISOC(5)                             GIONEUT  2355
C                                                                        GIONEUT  2356
      O2COL=O2COLM                                                       GIONEUT  2357
      IF(O2COLM .LT. 1.0E+15)  O2COL=1.1E+15                             GIONEUT  2358
      IF(O2COLM .GT. 2.0E+25)  O2COL=2.0E+25                             GIONEUT  2359
      LIMIT=15                                                           GIONEUT  2360
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                  GIONEUT  2361
      O3COL=O3COLM                                                       GIONEUT  2362
      IF(O3COLM .LT. 1.0E+12)  O3COL=1.1E+12                             GIONEUT  2363
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                             GIONEUT  2364
      LIMIT=12                                                           GIONEUT  2365
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                  GIONEUT  2366
      DISOC(5)=TRPLT2(J195,32,28,IO2,DELO2,IO3,DELO3)                    GIONEUT  2367
C                                                                        GIONEUT  2368
C  REACTION O3 + HV = O + O2 IN DISOC(6)                                 GIONEUT  2369
C                                                                        GIONEUT  2370
      O3COL=O3COLM                                                       GIONEUT  2371
      IF(O3COLM .LT. 1.0E+14)  O3COL=1.1E+14                             GIONEUT  2372
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                             GIONEUT  2373
      LIMIT=14                                                           GIONEUT  2374
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                  GIONEUT  2375
      DISOC(6)=TRPLT1(J194,IO3,DELO3)                                    GIONEUT  2376
C                                                                        GIONEUT  2377
C  REACTION NO2 + HV = NO + O1D IN DISOC(7)                              GIONEUT  2378
C                                                                        GIONEUT  2379
      O2COL=O2COLM                                                       GIONEUT  2380
      IF(O2COLM .LT. 1.0E+19)  O2COL=1.1E+19                             GIONEUT  2381
      IF(O2COLM .GT. 1.0E+25)  O2COL=1.0E+25                             GIONEUT  2382
      LIMIT=19                                                           GIONEUT  2383
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                  GIONEUT  2384
      O3COL=O3COLM                                                       GIONEUT  2385
      IF(O3COLM .LT. 1.0E+14)  O3COL=1.1E+14                             GIONEUT  2386
      IF(O3COLM .GT. 5.0E+18)  O3COL=5.0E+18                             GIONEUT  2387
      LIMIT=14                                                           GIONEUT  2388
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                  GIONEUT  2389
      DISOC(7)=TRPLT2(J200,19,15,IO2,DELO2,IO3,DELO3)                    GIONEUT  2390
C                                                                        GIONEUT  2391
C  REACTION N2O + HV = N2 + O1D IN DISOC(8)                              GIONEUT  2392
C                                                                        GIONEUT  2393
      O2COL=O2COLM                                                       GIONEUT  2394
      IF(O2COLM .LT. 1.0E+17)  O2COL=1.1E+17                             GIONEUT  2395
      IF(O2COLM .GT. 2.0E+25)  O2COL=2.0E+25                             GIONEUT  2396
      LIMIT=17                                                           GIONEUT  2397
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                  GIONEUT  2398
      O3COL=O3COLM                                                       GIONEUT  2399
      IF(O3COLM .LT. 1.0E+11)  O3COL=1.1E+11                             GIONEUT  2400
      IF(O3COLM .GT. 5.0E+19)  O3COL=5.0E+19                             GIONEUT  2401
      LIMIT=11                                                           GIONEUT  2402
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                  GIONEUT  2403
      DISOC(8)=TRPLT2(J201,26,27,IO2,DELO2,IO3,DELO3)                    GIONEUT  2404
C                                                                        GIONEUT  2405
C  REACTION HNO2 + HV = OH + OH IN DISOC(9)                              GIONEUT  2406
C                                                                        GIONEUT  2407
      O3COL=O3COLM                                                       GIONEUT  2408
      IF(O3COLM .LT. 1.0E+14)  O3COL=1.1E+14                             GIONEUT  2409
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    1     CONTINUE                                                          GIONEUT  2296
   35     O3COL=O3COLM                                                      GIONEUT  2297
          O2COL=O2COLM                                                      GIONEUT  2298
C                                                                           GIONEUT  2299
C  REACTION  O2 + HV = O + O1D IN DISOC(1)                                  GIONEUT  2300
C                                                                           GIONEUT  2301
          IF(O2COLM .LT. 1.0E+13)  O2COL=1.1E+13                            GIONEUT  2302
          IF(O2COLM .GT. 1.0E+22)  O2COL=1.0E+22                            GIONEUT  2303
          LIMIT=13                                                          GIONEUT  2304
          CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                 GIONEUT  2305
          O3COL=O3COLM                                                      GIONEUT  2306
          IF(O3COLM .LT. 1.0E+12)  O3COL=1.1E+12                            GIONEUT  2307
          IF(O3COLM .GT. 2.0E+19)  O3COL=1.9E+19                            GIONEUT  2308
          LIMIT=12                                                          GIONEUT  2309
          CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                 GIONEUT  2310
          DISOC(1)=TRPLT2(J193,28,26,IO2,DELO2,IO3,DELO3)                   GIONEUT  2311
C                                                                           GIONEUT  2312
C  REACTION O2 + HV = O + O IN DISOC(2)                                     GIONEUT  2313
C                                                                           GIONEUT  2314
          O2COL=O2COLM                                                      GIONEUT  2315
          IF(O2COLM .LT. 1.0E+17)  O2COL=1.1E+17                            GIONEUT  2316
          IF(O2COLM .GT. 2.0E+25)  O2COL=2.0E+25                            GIONEUT  2317
          LIMIT=17                                                          GIONEUT  2318
          CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                 GIONEUT  2319
          O3COL=O3COLM                                                      GIONEUT  2320
          IF(O3COLM .LT. 1.0E+13)  O3COL=1.1E+13                            GIONEUT  2321
          IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                            GIONEUT  2322
          LIMIT=13                                                          GIONEUT  2323
          CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                 GIONEUT  2324
          DISOC(2)=TRPLT2(J192,26,25,IO2,DELO2,IO3,DELO3)                   GIONEUT  2325
C                                                                           GIONEUT  2326
C  REACTION H2O + HV = OH + H IN DISOC(3)                                   GIONEUT  2327
C                                                                           GIONEUT  2328
          O2COL=O2COLM                                                      GIONEUT  2329
          IF(O2COLM .LT. 1.0E+13)  O2COL=1.1E+13                            GIONEUT  2330
          IF(O2COLM .GT. 1.0E+23)  O2COL=1.0E+23                            GIONEUT  2331
          LIMIT=13                                                          GIONEUT  2332
          CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                 GIONEUT  2333
          O3COL=O3COLM                                                      GIONEUT  2334
          IF(O3COLM .LT. 1.0E+11)  O3COL=1.1E+11                            GIONEUT  2335
          IF(O3COLM .GT. 5.0E+20)  O3COL=5.0E+20                            GIONEUT  2336
          LIMIT=11                                                          GIONEUT  2337
          CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                 GIONEUT  2338
          DISOC(3)=TRPLT2(J196,31,30,IO2,DELO2,IO3,DELO3)                   GIONEUT  2339
C                                                                           GIONEUT  2340
C  REACION H2O2 + HV = OH + OH IN DISOC(4)                                  GIONEUT  2341
C                                                                           GIONEUT  2342
          O2COL=O2COLM                                                      GIONEUT  2343
          IF(O2COLM .LT. 1.0E+17)  O2COL=1.1E+17                            GIONEUT  2344
          IF(O2COLM .GT. 5.0E+25)  O2COL=5.0E+25                            GIONEUT  2345
          LIMIT=17                                                          GIONEUT  2346
          CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                 GIONEUT  2347
          O3COL=O3COLM                                                      GIONEUT  2348
          IF(O3COLM .LT. 1.0E+12)  O3COL=1.1E+12                            GIONEUT  2349
          IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                            GIONEUT  2350
          LIMIT=12                                                          GIONEUT  2351
          CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                 GIONEUT  2352
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      SUBROUTINE DISSOC(DISOC,IALT)                                     GIONEUT  2239
C                                                                       GIONEUT  2240
      DIMENSION DISOC(14),O2C(12),PNO(12)                               GIONEUT  2241
C                                                                       GIONEUT  2242
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     GIONEUT  2243
C                                                                       GIONEUT  2244
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT  2245
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT  2246
C                                                                       GIONEUT  2247
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT  2248
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                         GIONEUT  2249
C                                                                       GIONEUT  2250
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)     GIONEUT  2251
C                                                                       GIONEUT  2252
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON          GIONEUT  2253
C                                                                       GIONEUT  2254
      COMMON/JAYS/J192(26,25),J193(28,26),J194(22),J195(32,28),         GIONEUT  2255
     1            J196(31,30),J197(27,28),J198(26,28),J200(19,15),      GIONEUT  2256
     2            J201(26,27),J202(22),J203(30,29),J204(35,28),J205(22) GIONEUT  2257
C                                                                       GIONEUT  2258
      COMMON/COLUM/O2COLM,O3COLM,DIS(19,59)                             GIONEUT  2259
C                                                                       GIONEUT  2260
      REAL N,MASS,J192,J193,J194,J195,J196,J197,J198,J200,J201,J202     GIONEUT  2261
      REAL J203,J204,J205                                               GIONEUT  2262
      LOGICAL JSTART                                                    GIONEUT  2263
      DATA JSTART/.TRUE./                                               GIONEUT  2264
C                                                                       GIONEUT  2265
C  THE FOLLOWING TWO DATA STATMENTS CONTAIN THE NO PHOTODISSOCIATION     GIONEUT  2266
C  RATE COEFFICIENTS (PNO) AS FUNCTIONS OF THE COLUMN DENSITY OF        GIONEUT  2267
C  O2 (O2C).  DATA FROM CIESLIK AND NICOLET, PLANET SPACE SCI.          GIONEUT  2268
C  21, 925, 1973.                                                       GIONEUT  2269
C                                                                       GIONEUT  2270
      DATA O2C/18.0,18.5,19.0,19.5,20.0,20.5,21.0,21.5,22.0,22.5,23.0,  GIONEUT  2271
     1        23.5/                                                     GIONEUT  2272
      DATA PNO/1.41E-5,1.40E-5,1.38E-5,1.33E-5,1.22E-5,1.02E-5,         GIONEUT  2273
     1         6.98E-6,3.58E-6,8.93E-7,1.26E-7,4.45E-12,1.50E-29/       GIONEUT  2274
C                                                                       GIONEUT  2275
      GRAVCOR(ZE)=1.0/((1.0+ZE/RADIUS)**2)                              GIONEUT  2276
C                                                                       GIONEUT  2277
C  COMPUTE COLUMN DENSITIES OF O2  AND O3 USING THE SWIDER              GIONEUT  2278
C  APPROXIMATION TO THE CHAPMAN FUNCTION.                               GIONEUT  2279
C                                                                       GIONEUT  2280
      ALT=Z(IALT)                                                       GIONEUT  2281
      T=(BOLTZ*TEMP(IALT))/(GRAV*GRAVCOR(ALT))                          GIONEUT  2282
      SCALE=T/MASS(8)                                                   GIONEUT  2283
      CALL CHAPMAN(CXI,ALT,RADIUS,SCALE,APPROX)                         GIONEUT  2284
      O2COLM=N(IALT,8)*SCALE*APPROX                                     GIONEUT  2285
      SCALE=T/MASS(9)                                                   GIONEUT  2286
      CALL CHAPMAN(CXI,ALT,RADIUS,SCALE,APPROX)                         GIONEUT  2287
      O3COLM=N(IALT,9)*SCALE*APPROX                                     GIONEUT  2288
      IF(.NOT. JSTART) GO TO 35                                         GIONEUT  2289
      JSTART=.FALSE.                                                    GIONEUT  2290
C                                                                       GIONEUT  2291
C  REDUCE THE NO PHOTODISSOCIATION RATE COFFICIENTS BY FACTOR OF 4.     GIONEUT  2292
C                                                                       GIONEUT  2293
      DO 1 II=1,12                                                      GIONEUT  2294
      PNO(II)=ALOG10(PNO(II)/4.0)                                       GIONEUT  2295
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      1            SUBROUTINE CHAPMAN(CXI,Z,R,H,F)                          GIONEUT  2210
                C                                                           GIONEUT  2211
                C  THIS SUBROUTINE COMPUTES AN APPROXIMATION FOR THE CHAPMAN GIONEUT  2212
                C  FUNCTION USING EQUATIONS F(2) AND FN OF SWIDER FROM      GIONEUT  2213
      5         C  'ON THE ACCURACY OF CERTAIN APPROXIMATIONS FOR THE CHAPMAN GIONEUT  2214
                C  FUNCTION' AFCRL-67-0468.                                 GIONEUT  2215
                C                                                           GIONEUT  2216
                     DATA PIOV2/1.570796326795/,SQPI2/8.862269254528E-01/   GIONEUT  2217
                     DATA PI/3.14159265359/                                 GIONEUT  2218
     10              X=(R+Z)/(H+1.0E-05)                                    GIONEUT  2219
                     Y=X*SIN(CXI)                                           GIONEUT  2220
                     IF(CXI .GT. PIOV2) GO TO 10                            GIONEUT  2221
                     W=X-Y                                                  GIONEUT  2222
                     IF(W .NE. 0.) GO TO 1                                  GIONEUT  2223
     15              F=SQRT(1.0+2.0*X)*SQPI2                                GIONEUT  2224
                     RETURN                                                 GIONEUT  2225
                1    A=SQRT(W)                                              GIONEUT  2226
                     IF(W .GE. 9.5) GO TO 5                                 GIONEUT  2227
                     COM=ERFC(A)                                            GIONEUT  2228
     20              F=-X*COS(CXI)+SQRT(1.0+2.0*X-W)*(A+SQPI2*COM*EXP(W))   GIONEUT  2229
                     RETURN                                                 GIONEUT  2230
                5    F=-X*COS(CXI)+SQRT(1.0+2.0*X-W)*(A+(1.0/(2.0*A))*(1.0  GIONEUT  2231
                    1  -(1.0/(2.0*W))+(3.0/(4.0*(W**2)))-(15.0/(8.0*(W**3))))) GIONEUT  2232
                     RETURN                                                 GIONEUT  2233
     25         10   A=-SQRT(Y/2.0)/TAN(CXI)                                GIONEUT  2234
                     EF=ERF(A)                                              GIONEUT  2235
                     F=SQRT(PI*Y/2.0)*(1.0+EF)                              GIONEUT  2236
                     RETURN                                                 GIONEUT  2237
                     END                                                    GIONEUT  2238
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      RETURN                                                            GIONEUT  2190
C                                                                       GIONEUT  2191
C  ERROR EXITS.                                                        GIONEUT  2192
C                                                                       GIONEUT  2193
20    PRINT 902, J,J1,JX,JH,X(J),X(J1),DX                               GIONEUT  2194
902   FORMAT(' ERROR IN YINT.     DX .LE. 0.',                          GIONEUT  2195
     1/' J=',I4,' J1=',I4,' JX=',I4,' JH=',I4,' X(J)=',1PE13.5,         GIONEUT  2196
     2' X(J1)=',E13.5,' DX=',E13.5)                                     GIONEUT  2197
      GO TO 910                                                         GIONEUT  2198
30    PRINT 903, JX,JH,XI,X(JX-1),X(JH)                                 GIONEUT  2199
903   FORMAT(' ERROR IN YINT.     XI OUTSIDE RANGE OF X.',              GIONEUT  2200
     1/' JX=',I4,' JH=',I4,' XI=',1PE13.5,' X(JX-1)=',E13.5,            GIONEUT  2201
     2' X(JH)=',E13.5)                                                  GIONEUT  2202
      GO TO 910                                                         GIONEUT  2203
40    PRINT 904, J,J1,JX,JH,X(J),X(J+1),DX1                             GIONEUT  2204
904   FORMAT(' ERROR IN YINT.     DX1 .LE. 0.',                         GIONEUT  2205
     1/' J=',I4,' J1=',I4,' JX=',I4,' JH=',I4,' X(J)=',1PE13.5,         GIONEUT  2206
     2' X(J+1)=',E13.5,' DX1=',E13.5)                                   GIONEUT  2207
910   STOP                                                              GIONEUT  2208
      END                                                               GIONEUT  2209
```

```
      FUNCTION YINT(XII,X,Y,JHI)                                        GIONEUT  2133
C                                                                       GIONEUT  2134
C  THIS FUNCTION RETURNS INTERPOLATED YINT FOR INPUT XII.  ARRAY X      GIONEUT  2135
C  MUST BE MONOTONICALLY INCREASING.  JHI IS NUMBER OF POINTS IN        GIONEUT  2136
C  X AND Y ARRAYS.                                                      GIONEUT  2137
C                                                                       GIONEUT  2138
C  INITIALIZE BY CALL WITH JHI=0 BEFORE EACH ARRAY CALL.                GIONEUT  2139
C                                                                       GIONEUT  2140
C  EXAMPLE                                                              GIONEUT  2141
C  INITIALIZE                                                           GIONEUT  2142
C   YY=YINT(XII,X,Y,0)                                                  GIONEUT  2143
C  LOOP ARRAY INTERPOLATE                                               GIONEUT  2144
C  DO 10 K=1,100                                                        GIONEUT  2145
C  XII=K                                                                GIONEUT  2146
C  10 YI(K)=YINT(XII,X,Y,JHI)                                           GIONEUT  2147
C                                                                       GIONEUT  2148
      DIMENSION X(1),Y(1)                                               GIONEUT  2149
      JH=JHI                                                            GIONEUT  2150
      XI=XII                                                            GIONEUT  2151
      IF(JH .GT. 0) GO TO 8                                             GIONEUT  2152
C  INITIALIZE                                                           GIONEUT  2153
      J1=0                                                              GIONEUT  2154
      RETURN                                                            GIONEUT  2155
8     IF(J1 .LT. 1) JX=2                                                GIONEUT  2156
      IF(J1 .LT. 1) GO TO 1                                             GIONEUT  2157
C  TEST IF XI BETWEEN CURRENT X(J1),X(J1+1)                             GIONEUT  2158
      IF(XI .GE. X(J1) .AND. XI .LE. X(J1+1)) GO TO 2                   GIONEUT  2159
C  SEARCH FOR STRADDLING X VALUES                                       GIONEUT  2160
1     DO 10 J=JX,JH                                                     GIONEUT  2161
      J1=J-1                                                            GIONEUT  2162
      DX=X(J)-X(J1)                                                     GIONEUT  2163
C  TEST FOR NON-ZERO DX                                                 GIONEUT  2164
      IF(DX .LE. 0.) GO TO 20                                           GIONEUT  2165
      IF(XI .GE. X(J1) .AND. XI .LE. X(J)) GO TO 4                      GIONEUT  2166
10    CONTINUE                                                          GIONEUT  2167
C ERROR                                                                 GIONEUT  2168
      GO TO 30                                                          GIONEUT  2169
C  COMPUTE SA=AVG SLOPE BETWEEN X(J1) AND X(J1+1)                       GIONEUT  2170
4     SA=(Y(J)-Y(J1))/DX                                                GIONEUT  2171
      JX=J                                                              GIONEUT  2172
C  SET PV,NXT SLOPE TO SA TEMPORARILY                                   GIONEUT  2173
      SAP=SAN=SA                                                        GIONEUT  2174
C  SET PVS SLOPE IF J1.GT.1                                             GIONEUT  2175
      IF(J1 .GT. 1) SAP=(Y(J1)-Y(J1-1))/(X(J1)-X(J1-1))                 GIONEUT  2176
      IF(J .GE. JH) GO TO 6                                             GIONEUT  2177
      DX1=X(J+1)-X(J)                                                   GIONEUT  2178
      IF(DX1 .LE. 0.) GO TO 40                                          GIONEUT  2179
C  SET NEXT SLOPE IF J1 .LT. JH1-1                                      GIONEUT  2180
      SAN=(Y(J+1)-Y(J))/DX1                                             GIONEUT  2181
6     S1=S2=0.                                                          GIONEUT  2182
      IF(SA*SAP .GT. 0.) S1=2.*SA*SAP/(SA+SAP)                          GIONEUT  2183
      IF(SA*SAN .GT. 0.) S2=2.*SA*SAN/(SA+SAN)                          GIONEUT  2184
      A2=(3.*SA-2.*S1-S2)/DX                                            GIONEUT  2185
      A3=(SA-S1-A2*DX)/DX/DX                                            GIONEUT  2186
C  THIS IS CUBIC FIT FOR STRADDLES XI                                   GIONEUT  2187
2     DXI=XI-X(J1)                                                      GIONEUT  2188
      YINT=Y(J1)+DXI*(S1+DXI*(A2+DXI*A3))                               GIONEUT  2189
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      IF(POWER .GT. 650.) GO TO 96                                      GIONEUT 2105
      EXPON=EXP(-POWER)                                                 GIONEUT 2106
   96 LYBETA=4.0E-03*SIGMA(4,2)*FLUX(2)*EXPON                           GIONEUT 2107
      POWER=AA*SIGMA(1,55)+AB*SIGMA(2,55)+AC*SIGMA(3,55)                GIONEUT 2108
  290 EXPON=0.                                                          GIONEUT 2109
      IF(POWER .GT. 650.) GO TO 100                                     GIONEUT 2110
      EXPON=EXP(-POWER)                                                 GIONEUT 2111
  100 HEI=1.1E-03*FLUX(55)*EXPON                                        GIONEUT 2112
      POWER=AA*SIGMA(1,68)+AB*SIGMA(2,68)+AC*SIGMA(3,68)                GIONEUT 2113
  295 EXPON=0.                                                          GIONEUT 2114
      IF(POWER .GT. 650.) GO TO 105                                     GIONEUT 2115
      EXPON=EXP(-POWER)                                                 GIONEUT 2116
  105 HEII=1.0E-03*FLUX(68)*EXPON                                       GIONEUT 2117
      DK(185)=DK(185)+HEI*SIGMA(6,55)+HEII*SIGMA(6,68)                  GIONEUT 2118
  300 DK(186)=DK(186)+LYBETA+HEI*SIGMA(4,55)+HEII*SIGMA(4,68)           GIONEUT 2119
      DK(187)=DK(187)+HEI*SIGMA(5,55)+HEII*SIGMA(5,68)                  GIONEUT 2120
      DK(188)=DK(188)+LYALFA                                            GIONEUT 2121
      DK(190)=DK(190)+HEI*SIGMA(7,55)+HEII*SIGMA(7,68)                  GIONEUT 2122
      DK(191)=DK(191)+HEI*SIGMA(8,55)+HEII*SIGMA(8,68)                  GIONEUT 2123
  305 C                                                                 GIONEUT 2124
      C  ADD COSMIC RAY IONIZATION.  Q=1.0E-17*N                        GIONEUT 2125
      C                                                                 GIONEUT 2126
      DO 110 I=185,191                                                  GIONEUT 2127
      DK(I)=DK(I)+COSMIC                                                GIONEUT 2128
  310 110 CONTINUE                                                      GIONEUT 2129
      DK(206)=DK(185)                                                   GIONEUT 2130
      RETURN                                                            GIONEUT 2131
      END                                                               GIONEUT 2132
```

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      R(58)=K(58)*Y(48)*Y(13)*Y(23)                                     GIONEUT  2652
      R(59)=K(59)*Y(49)*Y(13)                                           GIONEUT  2653
      R(60)=K(60)*Y(48)*Y(13)                                           GIONEUT  2654
      R(61)=K(61)*Y(47)*Y(13)                                           GIONEUT  2655
      R(62)=K(62)*Y(41)*Y(35)                                           GIONEUT  2656
      R(63)=K(63)*Y(41)*Y(36)                                           GIONEUT  2657
      R(64)=K(64)*Y(41)*Y(37)                                           GIONEUT  2658
      R(65)=K(65)*Y(42)*Y(32)                                           GIONEUT  2659
      R(66)=K(66)*Y(42)*Y(35)                                           GIONEUT  2660
      R(67)=K(67)*Y(42)*Y(36)                                           GIONEUT  2661
      R(68)=K(68)*Y(42)*Y(37)                                           GIONEUT  2662
      R(69)=K(69)*Y(42)*Y(38)                                           GIONEUT  2663
      R(70)=K(70)*Y(43)*Y(35)                                           GIONEUT  2664
      R(71)=K(71)*Y(43)*Y(36)                                           GIONEUT  2665
      R(72)=K(72)*Y(43)*Y(37)                                           GIONEUT  2666
      R(73)=K(73)*Y(43)*Y(38)                                           GIONEUT  2667
      R(74)=K(74)*Y(44)*Y(35)                                           GIONEUT  2668
      R(75)=K(75)*Y(44)*Y(36)                                           GIONEUT  2669
      R(76)=K(76)*Y(44)*Y(37)                                           GIONEUT  2670
      R(77)=K(77)*Y(44)*Y(38)                                           GIONEUT  2671
      R(78)=K(78)*Y(45)*Y(35)                                           GIONEUT  2672
      R(79)=K(79)*Y(45)*Y(36)                                           GIONEUT  2673
      R(80)=K(80)*Y(45)*Y(37)                                           GIONEUT  2674
      R(81)=K(81)*Y(45)*Y(38)                                           GIONEUT  2675
      R(82)=K(82)*Y(51)*Y(35)                                           GIONEUT  2676
      R(83)=K(83)*Y(51)*Y(36)                                           GIONEUT  2677
      R(84)=K(84)*Y(51)*Y(37)                                           GIONEUT  2678
      R(85)=K(85)*Y(52)*Y(35)                                           GIONEUT  2679
      R(86)=K(86)*Y(52)*Y(36)                                           GIONEUT  2680
      R(87)=K(87)*Y(52)*Y(37)                                           GIONEUT  2681
      R(88)=K(88)*Y(53)*Y(35)                                           GIONEUT  2682
      R(89)=K(89)*Y(53)*Y(36)                                           GIONEUT  2683
      R(90)=K(90)*Y(53)*Y(37)                                           GIONEUT  2684
      R(91)=K(91)*Y(48)*Y(36)                                           GIONEUT  2685
      R(92)=K(92)*Y(48)*Y(37)                                           GIONEUT  2686
      R(93)=K(93)*Y(48)*Y(38)                                           GIONEUT  2687
      R(94)=K(94)*Y(49)*Y(37)                                           GIONEUT  2688
      R(95)=K(95)*Y(49)*Y(38)                                           GIONEUT  2689
      R(96)=K(96)*Y(31)                                                 GIONEUT  2690
      R(97)=K(97)*Y(31)*Y(7)                                            GIONEUT  2691
      R(98)=K(98)*Y(31)*Y(9)                                            GIONEUT  2692
      R(99)=K(99)*Y(32)                                                 GIONEUT  2693
      R(100)=K(100)*Y(32)*Y(7)                                          GIONEUT  2694
      R(101)=K(101)*Y(32)*Y(7)                                          GIONEUT  2695
      R(102)=K(102)*Y(32)*Y(9)                                          GIONEUT  2696
      R(103)=K(103)*Y(32)*Y(20)                                         GIONEUT  2697
      R(104)=K(104)*Y(33)                                               GIONEUT  2698
      R(105)=K(105)*Y(33)                                               GIONFUT  2699
      R(106)=K(106)*Y(33)*Y(7)                                          GIONEUT  2700
      R(107)=K(107)*Y(34)*Y(7)                                          GIONEUT  2701
      R(108)=K(108)*Y(34)*Y(7)                                          GIONEUT  2702
      R(109)=K(109)*Y(34)*Y(25)                                         GIONEUT  2703
      R(110)=K(110)*Y(37)                                               GIONEUT  2704
      R(111)=K(111)*Y(37)*Y(7)                                          GIONEUT  2705
      R(112)=K(112)*Y(37)*Y(19)                                         GIONEUT  2706
      R(113)=K(113)*Y(38)                                               GIONEUT  2707
      R(114)=K(114)*Y(38)                                               GIONEUT  2708
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      R(115)=K(115)*Y(38)*Y(7)                                          GIONEUT 2709
      R(116)=K(116)*Y(38)*Y(9)                                          GIONEUT 2710
      R(117)=K(117)*Y(38)*Y(18)                                         GIONEUT 2711
  175 R(118)=K(118)*Y(35)                                               GIONEUT 2712
      R(119)=K(119)*Y(35)*Y(9)                                          GIONEUT 2713
      R(120)=K(120)*Y(36)                                               GIONEUT 2714
      R(121)=K(121)*Y(36)*Y(7)                                          GIONEUT 2715
      R(122)=K(122)*Y(56)*Y(18)                                         GIONEUT 2716
  180 R(123)=K(123)*Y(36)                                               GIONEUT 2717
      R(124)=K(124)*Y(31)*Y(9)                                          GIONEUT 2718
      R(125)=K(125)*Y(29)*Y(23)                                         GIONEUT 2719
      R(126)=K(126)*Y(29)*Y(8)                                          GIONEUT 2720
      R(127)=K(127)*Y(3)*Y(25)                                          GIONEUT 2721
  185 R(128)=K(128)*Y(7)*Y(7)*Y(57)                                     GIONEUT 2722
      R(129)=K(129)*Y(7)*Y(8)*Y(57)                                     GIONEUT 2723
      R(130)=K(130)*Y(7)*Y(9)                                           GIONEUT 2724
      R(131)=K(131)*Y(7)*Y(15)                                          GIONEUT 2725
      R(132)=K(132)*Y(7)*Y(14)                                          GIONEUT 2726
  190 R(133)=K(133)*Y(7)*Y(14)                                          GIONEUT 2727
      R(134)=K(134)*Y(11)*Y(14)                                         GIONEUT 2728
      R(135)=K(135)*Y(11)*Y(14)                                         GIONEUT 2729
      R(136)=K(136)*Y(11)*Y(8)*Y(57)                                    GIONEUT 2730
      R(137)=K(137)*Y(16)*Y(8)                                          GIONEUT 2731
  195 R(138)=K(138)*Y(16)*Y(18)                                         GIONEUT 2732
      R(139)=K(139)*Y(16)*Y(7)*Y(57)                                    GIONEUT 2733
      R(140)=K(140)*Y(10)*Y(9)                                          GIONEUT 2734
      R(141)=K(141)*Y(10)*Y(14)                                         GIONEUT 2735
      R(142)=K(142)*Y(18)*Y(9)                                          GIONEUT 2736
  200 R(143)=K(143)*Y(18)*Y(7)*Y(57)                                    GIONEUT 2737
      R(144)=K(144)*Y(12)*Y(12)                                         GIONEUT 2738
      R(145)=K(145)*Y(12)*Y(9)                                          GIONEUT 2739
      R(146)=K(146)*Y(19)*Y(11)                                         GIONEUT 2740
      R(147)=K(147)*Y(26)*Y(10)                                         GIONEUT 2741
  205 R(148)=K(148)*Y(26)*Y(7)*Y(57)                                    GIONEUT 2742
      R(149)=K(149)*Y(17)*Y(30)                                         GIONEUT 2743
      R(150)=K(150)*Y(5)*Y(30)                                          GIONEUT 2744
      R(151)=K(151)*Y(5)*Y(30)                                          GIONEUT 2745
      R(152)=K(152)*Y(4)*Y(30)                                          GIONEUT 2746
  210 R(153)=K(153)*Y(3)*Y(30)                                          GIONEUT 2747
      R(154)=K(154)*Y(6)*Y(30)                                          GIONEUT 2748
      R(155)=K(155)*Y(1)*Y(30)                                          GIONEUT 2749
      R(156)=K(156)*Y(40)*Y(30)                                         GIONEUT 2750
      R(157)=K(157)*Y(51)*Y(30)                                         GIONEUT 2751
  215 R(158)=K(158)*Y(52)*Y(30)                                         GIONEUT 2752
      R(159)=K(159)*Y(53)*Y(30)                                         GIONEUT 2753
      R(160)=K(160)*Y(8)*Y(8)*Y(30)                                     GIONEUT 2754
      R(161)=K(161)*Y(9)*Y(30)                                          GIONEUT 2755
      R(162)=K(162)*Y(4)*Y(8)*Y(57)                                     GIONEUT 2756
  220 R(163)=K(163)*Y(39)*Y(57)                                         GIONEUT 2757
      R(164)=K(164)*Y(39)*Y(23)                                         GIONEUT 2758
      R(165)=K(165)*Y(5)*Y(25)*Y(23)                                    GIONEUT 2759
      R(166)=K(166)*Y(5)*Y(13)*Y(57)                                    GIONEUT 2760
      R(167)=K(167)*Y(28)*Y(8)                                          GIONEUT 2761
  225 R(168)=K(168)*Y(3)*Y(23)                                          GIONEUT 2762
      R(169)=K(169)*Y(3)*Y(8)                                           GIONEUT 2763
      R(170)=K(170)*Y(41)*Y(13)*Y(57)                                   GIONEUT 2764
      R(171)=K(171)*Y(41)*Y(23)*Y(23)                                   GIONEUT 2765
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      R(172)=K(172)*Y(42)*Y(13)*Y(57)                                    GIONEUT  2766
230   R(173)=K(173)*Y(43)*Y(13)*Y(57)                                    GIONEUT  2767
      R(174)=K(174)*Y(43)*Y(57)                                          GIONEUT  2768
      R(175)=K(175)*Y(44)*Y(57)                                          GIONEUT  2769
      R(176)=K(176)*Y(45)*Y(57)                                          GIONEUT  2770
      R(177)=K(177)*Y(51)*Y(13)*Y(57)                                    GIONEUT  2771
235   R(178)=K(178)*Y(52)*Y(13)*Y(57)                                    GIONEUT  2772
      R(179)=K(179)*Y(31)*Y(8)*Y(8)                                      GIONEUT  2773
      R(180)=K(180)*Y(32)*Y(8)*Y(8)                                      GIONEUT  2774
      R(181)=K(181)*Y(32)*Y(8)*Y(25)                                     GIONEUT  2775
      R(182)=K(182)*Y(33)*Y(25)                                          GIONEUT  2776
240   R(183)=K(183)*Y(34)*Y(57)                                          GIONEUT  2777
      R(184)=K(184)*Y(37)*Y(18)                                          GIONEUT  2778
      R(185)=K(185)*Y(7)                                                 GIONEUT  2779
      R(186)=K(186)*Y(8)                                                 GIONEUT  2780
      R(187)=K(187)*Y(23)                                                GIONEUT  2781
245   R(188)=K(188)*Y(18)                                                GIONEUT  2782
      R(189)=K(189)*Y(16)                                                GIONEUT  2783
      R(190)=K(190)*Y(11)                                                GIONEUT  2784
      R(191)=K(191)*Y(21)                                                GIONEUT  2785
      R(192)=K(192)*Y(8)                                                 GIONEUT  2786
250   R(193)=K(193)*Y(8)                                                 GIONEUT  2787
      R(194)=K(194)*Y(9)                                                 GIONEUT  2788
      R(195)=K(195)*Y(9)                                                 GIONEUT  2789
      R(196)=K(196)*Y(13)                                                GIONEUT  2790
      R(197)=K(197)*Y(14)                                                GIONEUT  2791
255   R(198)=K(198)*Y(12)                                                GIONEUT  2792
      R(199)=K(199)*Y(18)                                                GIONEUT  2793
      R(200)=K(200)*Y(19)                                                GIONEUT  2794
      R(201)=K(201)*Y(24)                                                GIONEUT  2795
      R(202)=K(202)*Y(55)                                                GIONEUT  2796
260   R(203)=K(203)*Y(25)                                                GIONEUT  2797
      R(204)=K(204)*Y(25)                                                GIONEUT  2798
      R(205)=K(205)*Y(56)                                                GIONEUT  2799
      R(206)=K(206)*Y(7)                                                 GIONEUT  2800
      R(207)=K(207)*Y(20)                                                GIONEUT  2801
265   R(208)=K(208)*Y(23)                                                GIONEUT  2802
      R(209)=K(209)*Y(8)                                                 GIONEUT  2803
      R(210)=K(210)*Y(8)                                                 GIONEUT  2804
      R(211)=K(211)*Y(7)                                                 GIONEUT  2805
      R(212)=K(212)*Y(7)                                                 GIONEUT  2806
270   R(213)=K(213)*Y(23)                                                GIONEUT  2807
      R(214)=K(214)*Y(8)                                                 GIONEUT  2808
      R(215)=K(215)*Y(23)                                                GIONEUT  2809
      NN=NREAC+NREAC2                                                    GIONEUT  2810
      WRITE(6,20) (J,(CYMB(I,J),I=1,6),K(J),R(J),J=1,NN)                 GIONEUT  2811
275   20  FORMAT(I4,5A10,A8,9X,1PE12.5,9X,E12.5)                         GIONEUT  2812
      RETURN                                                             GIONEUT  2813
      END                                                                GIONEUT  2814
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      SUBROUTINE HOUR(TIME,OUTP)                                        GIONEUT 2815
C                                                                       GIONEUT 2816
C  THIS SUBROUTINE CONVERTS THE VALUE OF TIME IN SECONDS TO             GIONEUT 2817
C  HOURS.                                                               GIONEUT 2818
C                                                                       GIONEUT 2819
      DIMENSION W(10),OUTP(1)                                           GIONEUT 2820
      DATA W/1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1H0/                   GIONEUT 2821
      T=TIME+4.32E+04                                                   GIONEUT 2822
      R=AMOD(T,8.64E+04)                                                GIONEUT 2823
      HR=R/3600.+0.00001                                                GIONEUT 2824
      IHR=HR                                                            GIONEUT 2825
      FHR=HR-FLOAT(IHR)                                                 GIONEUT 2826
      IFHR=FHR*60.01                                                    GIONEUT 2827
      JL=4                                                              GIONEUT 2828
      DO 5 L=1,2                                                        GIONEUT 2829
      IF(L .EQ. 1) IW=IFHR                                              GIONEUT 2830
      IF(L .EQ. 2) IW=IHR                                               GIONEUT 2831
      DO 5 M=1,2                                                        GIONEUT 2832
      II=MOD(IW,10)                                                     GIONEUT 2833
      IF(II .EQ. 0) II=10                                               GIONEUT 2834
      OUTP(JL)=W(II)                                                    GIONEUT 2835
      JL=JL-1                                                           GIONEUT 2836
      IW=IW/10                                                          GIONEUT 2837
5     CONTINUE                                                          GIONEUT 2838
      RETURN                                                            GIONEUT 2839
      END                                                               GIONEUT 2840
```

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